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AIRBASE OPERATIONS

IN A CHEMICAL ENVIRONMENT

THESIS

Robert Edward Taft, Captain, USAF

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AIRBASE OPERATIONS IN A CHEMICAL ENVIRONMENT

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

by

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Graduate Strategic and Tactical Sciences

March 1982

Approved for release publicly, distribution unlimited

Preface

In 1978, the Special Operations Wing at Hurlbert Field, Florida, became involved in training in the Aircrew Chemical Defense Ensemble. As a Life Support Officer for one of the three operational squadrons, I became directly involved in this test program that was conducted by the Tactical Air Warfare Center. Having flown in the ensemble, and therefore realizing some of its limitations, my interest in this field continued. The reports of chemical agents being used in Afghanistan and Southeast Asia stimulated both my interest and that of the Air Force.

I would like to acknowledge the help received from the Chemical Defense Division of the Aerospace Medical Research Laboratory. They provided publications in the field of air base operations and chemical effects, most of which were unpublished. The aid from instructors and fellow students in the field of computerization and statistics was greatly appreciated.

For the many months this thesis was worked on, from conceptualization and model development to final typing, heart-felt thanks is extended to my wife, Lara. Without her support, this thesis would not have been finished.

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Abstract

This thesis studies the effects of maintenance operations on a fighter base in a chemical environment. The desired goal is to determine if current manning for flight line maintenance is sufficient to support air operations.

A simulation model was developed to model the required tasks of maintenance in a wartime surge. The effects of wearing chemically protective clothing was incorporated to measure the results of operating with different numbers of aircraft and maintenance available. Analysis was performed using nonparametric tests, due to the nature of the data. The results of these tests indicate that the present manning is not sufficient.

Material is presented in the appendices that shows the nature of improvements being made in the chemical defense ensembles and aircraft systems. These improvements may reduce the limitations that are present in the current equipment used.

AIR BASE OPERATIONS IN A CHEMICAL ENVIRONMENT

I. Introduction

Historical Background

The first use of chemical warfare can be traced back to World War I. The Germans used Phosgene and Mustard gas against French and Canadian forces at the battle at Ypres in 1915. This caused fifteen thousand casualties the first day (Ref.3:35). To reduce the possibilities of this type warfare being used again after World War I, the major powers put together the Geneva Protocol in 1925. The Geneva Protocol was against the use of gas (chemical weapons) by regular military forces. The problem arose, however, in that the major powers did not sign the Protocol. In 1928, the Soviet Union signed the Protocol, but with a stipulation, never to employ "first use" of poison gas against an adversary that had also signed the Protocol (Ref.15:35). In 1948, Trygve Lie, the first General Secretary of the United Nations, made the following statement:

> . . . The extended debate over the control of atomic energy and the emmense destructive force of the atomic weapons which the United States has supplied to the world, has detracted attention from the developments in the field of bacteriological or chemical weapons. Some of these weapons are potentially as destructive to human

life as atomic weapons, but in spite of this fact not a single proposal for a system of prevention or control of their manufacture has been made by any member state, nor has there ever been any discussion or study of this problem within the United Nations. In the meantime, it is not incorrect to assume that, as with the case of atomic bombs, stocks of these weapons are increasing and that there are continuous new developments which make their use even deadlier. (Ref. 12:30)

Chemical agents were not publically used again until the United States started using defoliants and crowd-control agents in Viet Nam. President Nixon, in 1969, declared the United States would not produce or use biological weapons, and would destroy those in stockpile. He also stated the United States would, however, use chemical weapons in a retaliatory action if attacked with chemicals first (Ref. 1:12-17). On January 22, 1975, President Ford signed the Geneva Protocol of 1925, and the Biological Warfare Convention, the "first use" stipulation was included (Ref. 5:2).

From the mid-1970s to date, the Tactical Air Warfare Center at Eglin Air Force Base, Florida, has been developing Ground and Aircrew Chemical Defense Ensembles; and the threat has become more blatant (Ref. 13:4). In 1976, the Laotian General Vang Pao claimed the Soviet supported Pathet Lao were using chemical weapons on his irregular army. Reports of cases in Laos and Cambodia increased from 1976 to early 1980, at which time General Pikolov, chief of the Soviet Chemical Troops, was reported to be in Indochina. It was at this time that Soviet decontaminant equip-

ment appeared in Afghanistan and

> . . . after Soviet and Afghan troops were unsuccessful in subduing Afghan rebels in their mountain redoubts, they began to spray poison gases into ravines and surrounding areas. This began in about mid-March 1980 (Ref.18:53).

To combat this new threat, the Department of Defense requested $43.8 million for chemical defense equipment research and development, for fiscal year 1981. They also requested over $20 million be spent on the procurement of equipment for that year (Ref.10:46).

The Current Threat

The Soviet Union has been developing a formidable force of chemical weapons since the mid-1950s. According to Professor John Erickson, a consultant on Soviet policy to the United Nations and the U.S. Department of Defense, the Soviet leaders

> . . . do not dismiss the possibility of a 'large scale' resort to chemical weapons, both in theater operations and in targeting civilian populations in the rear . . . . chemical weapons . . . are especially suitable for use in 'surprise attacks' against enemy forces . . . (Ref.6:64).

Targeting airfields with non-persistant agents that wear off in a matter of days, or even hours, is considered reasonable. These agents could be launched from forward units by tactical missiles, such as Frog or Scud, which have a range of 20 kilometers. More probable is attack by aircraft using rockets and bombs filled with nerve and blood

agents (see Appendix A). These would kill or incapacitate the forces at the airfield, yet leave intact the runway and facilities, if the personnel were not protected in some way (Ref.6:65).

The Soviets can consider performance of this type act because they are more capable of operating in this environment. They have 10 percent of their army, at least 80,000 men, in the Soviet Chemical Troops (Ref.3:34). These forces have the primary mission of detecting chemical and biological agents and decontaminating equipment, personnel, and even the ground (Ref.6:69). The individual troops, both air and ground, know the capabilities of the chemical defense equipment they are issued. They receive extensive hands-on training, including subjection to dilute agents and long-term exercises simulating operations in a chemical environment. The bottom line is that the Soviets do not "consider chemical warfare a special form of military struggle" (Ref.5:4).

Problem Statement

The operations of an air base during wartime are rigorous and complex. The functions of the maintenance teams to prepare aircraft for launch are hampered by attack and the fear of attack. The scenario developed in this thesis is of just such an attack, not by conventional or nuclear munitions, but by chemicals.

Currently, maintenance teams are assigned to fighter-

type aircraft at a ratio of one team for three aircraft (Ref.25:10-22). With the increased burden of working on aircraft in chemically protective clothing, the amount of time required to generate aircraft should increase. The current chemical defense ensembles are presented in Appendix E. This increased time should change the number of flights per day capable of taking-off. The most common measure of effectiveness of this capability of maintenance to operate is the turn rate. The turn rate is a measure of the number of times each aircraft is capable of flying during one day. This rate is primarily a function of the number of aircraft and maintenance teams available, the time to perform the required maintenance, and for this scenario, the effects of operations in a chemical environment. By making comparisons between these factors, the number of maintenance teams required to meet an established turn rate can be measured. A simulation model was developed to make data available to make these comparisons.

Objectives

To measure the effectiveness of maintenance to operate in a chemical environment, some means of making comparisons showing the effects of changing maintenance levels is required. The first objective of this study was, therefore, the creation of a viable simulation model to make comparisons. Research into the inputs of aircraft

generation and effects of the chemical environment were the basis for the model creation. After the model was verified for each phase of operation, comparisons of the data could be made.

As previously mentioned, the most common measure of effectiveness for this type study is the turn rate. Without knowing the effects of changing the ratio of aircraft to maintenance, the turn rate does not give a clear understanding of effectiveness. By showing the effects of resource modifications in aircraft, personnel, and equipment, a clearer picture of the amount of personnel required to operate an airfield is presented. A method of ascertaining the number of maintenance teams required to meet this goal is the second objective. The methodology used to meet these two objectives is presented in the overview.

Overview

The development of the simulation model is an ongoing process. The research into a particular problem, in this case chemical warfare operations, requires the researcher to gain an understanding of this problem and many related areas to approach an answer. The methodology used in this thesis followed a similar approach.

The reasons for investigating the topic of air operation, as a function of maintenance, is presented in Chap-

ter I. With the threat of chemical weapons being used in a conflict, a means to establish manning requirements for the maintenance of fighter aircraft is crucial. The method used to answer this question was the development of a simulation model.

Chapter II covers the development of the simulation model used, from conceptualization through its final form. The conceptual model is presented in the form of a causal loop diagram, to show the major areas required to be modeled. Through further research, these terms were more fully defined, and an experimental model was developed. This model was then used to create a simulation model using the Q-GERT simulation language. Throughout the development of the model the objective of required manning was in the forefront. This was to limit the inclusion of unnessary detail in the model and to provide a framework to make analysis.

The model output is analised in Chapter III. The effects of changing the control variables and some of the stochastic variables is presented.

A nonparametric test, the Friedman test, was used in the analysis. This test uses the ranked order of the raw data to make comparisons between the levels of maintenance and aircraft modeled. The test is very similar to the parameter test of a one-way Analysis of Variance

(ANOVA). This parametric test could not be used due to the restrictive nature of the assumptions for its use. These restrictions are removed when using the nonparametric test. By looking at the effects of these changes, as they apply to the turn rate of the aircraft, conclusions and recommendations can be drawn.

Chapter IV covers the conclusions drawn from the analysis and lists several recommendations for improvements in both the chemical defense ensemble used by the maintenance personnel and to the model. The changes in the model are for increasing its usefulness in analizing air base operations to monitor supply utilization and add futher realism.

II. Model Development

Introduction

Construction of the model began with a literature search of relevant material dealing with fighter aircraft maintenance and chemical warfare. From this research, a causal loop diagram was constructed and used as the basis for a simulation model using the Q-GERT computer language. The main impetus behind the construction of the basic model was a research effort done by Quest Research Corporation (Ref.25), on air base operations in a chemical environment. The physical layout and capabilities of Ramstein Air Base, Germany, provided an input to the model. After the basic model was developed, it was expanded to include the factors encountered in aircraft generation, and used to collect data. This data will be used to answer the question of maintenance personnel required to meet the desired goal of aircraft turn rate.

Structural Model

A preliminary model to aid in both the conceptualization of the problem, and as the basis for establishment of a network using the Q-GERT simulation language (Ref.14), a causal loop diagram was constructed, Figure 1. As the values of the elements enclosed in brackets goes up, the

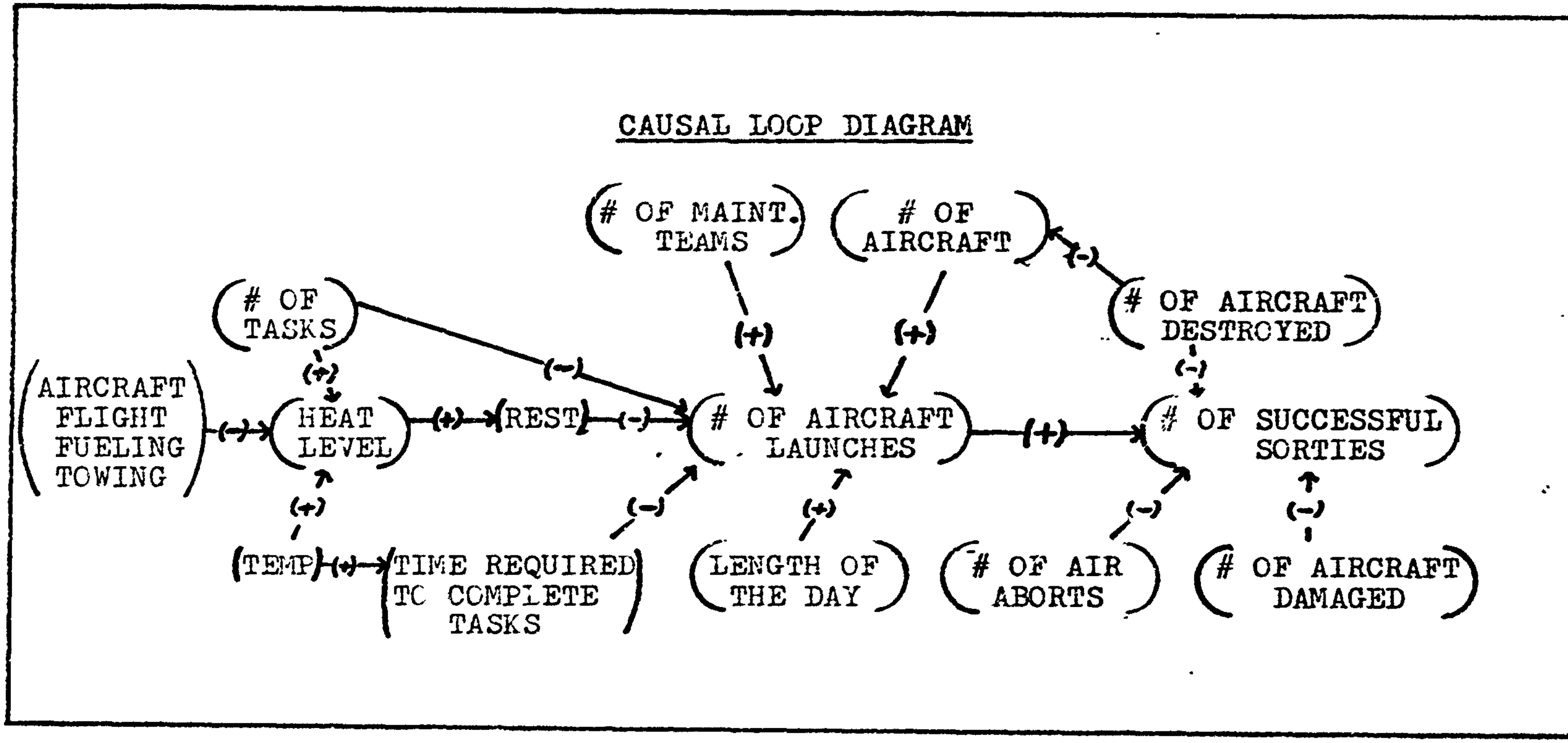

Fig. 1 Causal Loop Diagram

Table I

DEFINITION OF TERMS USED IN THE CAUSAL LOOP DIAGRAM

# of Aircraft	The number of available aircraft
Temp	The external ambient temperature and humidity (taken as fixed in this model as 70 F and 15%)
Aircraft Flight Fueling & Towing	Time spent flying, fueling, and towing aircraft
# of Tasks	The number of tasks that need to be performed to take the aircraft from landing to ready for take-off
# of Maint Teams	The number of teams available to perform maintenance on the aircraft
Time Required to Complete Tasks	The time required to perform each individual task
Rest	Delay time if team members Heat Build-up level exceeds a set value
Heat Level	Generated heat build-up inside protective clothing
Length of the Day	Time maintenance teams show for work until end of one day (1440 min)
# of Aircraft Launches	Total number of aircraft launched
# of Aircraft Damaged	Aircraft damaged but repairable
# of Aircraft Destroyed	The number of aircraft destroyed
# of Air Aborts	Aircraft with a flight time of 15 minutes or less
# of Successful Sorties	The number of aircraft launched reduced by those destroyed or air aborted

effect it has on the targeted element is increased if a plus (+) is indicated or decreased in its value if a minus (-). Table I contains definitions of terms used in the causal loop diagram.

The variables included in the model, as shown in the causal loop diagram, are the basic variables in the generation of aircraft by maintenance and sorties flown. With a given number of aircraft and maintenance teams, and the times to complete all required tasks, the time to turn an aircraft can be calculated.

The variables from the structural model were broken down into the following categories:

Table II

Stochastic Variables	# of tasks Time required to complete tasks Temp Aircraft Flight, Fueling & Towing Heat Level Rest Length of Day Percentage of aircraft destroyed Percentage of aircraft damaged # of Air Aborts
Control Variables	# of aircraft # of maintenance teams
Response Variables	# of aircraft launched # of aircraft generated # of successful sorties

By varying the control variables over a range and measureing the response variables, the desired levels of the control variables can be predicted to meet the required sortie turn rate. This response is measured by comparison with the desires of a theater commander to support his mission, and to minimize the hazards on his maintenance personnel in a chemical environment.

Assumptions

Several assumptions were required in the development of the thesis model. They shall be listed now, before describing the experimental model, to set the background for the rest of the model. The reasons for their use are also given.

1. The airfield is attacked with only chemical weapons. In this way the resourses are not removed from the model due to destruction by conventional weapons while on the ground. The start-up conditions can be specified at the beginning of the simulation model run to impose the burden of operations in a chemical environment only on the results.

2. The alert status of the field has been upgraded prior to the attack. This is to ensure that all personnel are capable of surviving the attack. Decontamination equipment and chemically protective clothing are immediately available to all personnel.

3. All aircraft available at the start of the model have all maintenance completed on them. The normal functions of maintenance is to perform the required maintenance prior to the start of the following day. This would be done in an upgraded alert status.

4. The external ambient temperature and humidity are fixed at 70 F and 15% humidity. Heat stress is a major problem while wearing chemically protective clothing. To simulate this condition, the rate of heat dissipation must be calculable, as must be the rate of heat generation, both of which are functions of atmospheric conditions.

5. All personnel available at the start of the run are capable of working for the entire one day scenario (with the exception of crewmembers lost in destroyed aircraft). There are sufficient aircrew members available to fly the aircraft that are generated. During rest periods and refueling the maintenance teams are periodically transported to a secure, non-contaminated area to perform normal bodily functions and to change their chemical defense ensembles. The ensembles must be changed approximately every six hours, their considered useful life in a chemical environment. All individuals in a maintenance team are considered to be equally vulnerable, and thus are equally affected by the conditions.

6. Supply levels of fuel and munitions are unlimited.

If the threat of attack is imminent, the airfield should have sufficient fuel and munitions for at least one day.

7. After landing, all aircraft must go through the maintenance cycle. The maintenance that is modeled depicts the activities during a wartime surge, and therefore must be performed as a minimum. The time spent going through this cycle increases the delay on aircraft that air abort or are damaged, for required maintenance. This is to simulate the difficulty of locating and fixing maintenance problems while the personnel are wearing chemically protective clothing.

8. The threat of continued chemical attack is such that the entire ensemble must be worn for the one day scenario. The distributions on task times are therefore not changed during the run.

The simulation model is used to make comparisons between differing levels of maintenance and aircraft, and to recommend manning requirements to meet a desired turn rate.

Experimental Design

To generate a model, the variables and their values must be defined. This section shall expand on the variables used in the model presented in Figure 1. By use of the above assumptions, distribution types can be used to model the times required in performing each task of air-

craft and fuel truck operations.

Several sources were consulted as to the tasks that needed to be performed and the times to complete them. This data was finally taken from a document called The F-4E Aircraft Maintenance Support General Job Standards (Ref. 21). This document is currently used by the Tactical Air Command (TAC) to simulate fighter aircraft generation. The tasks required to take an aircraft from landing to its next launch in a wartime surge environment, as used in this model are: an Aero 7 inspection, reloading of the 20 mm gun, refueling, uploading of missiles, and preflight. Movement of the aircraft on the ground and the time it is in flight must be modeled to simulate the activities performed in the operations of an airfield. These areas and the physical resources of the field are taken into consideration in the development of the simulation model to ensure a measure of accuracy in modeling.

The Aero 7 inspection is a post flight inspection on the aircraft. The aircraft basic systems are inspected to ensure that the maintenance tasks required on it can be done safely and that it is capable of a follow-on flight. The major areas inspected are the electrical, hydralic, fuel, and armament systems. The reloading of the 20 mm internally mounted gun is performed to give the aircraft both an air-to-air and an air-to-ground capability. This

task is started as soon as cleared by the personnel performing the Aero 7 inspection.

The refueling of the aircraft can be performed at either the hotpit or by fuel truck after the aircraft is parked. Aircraft use of the hotpit is a function of both its external fuel tank configuration and the availability of the hotpit. The hotpit has a physical limitation of only being able to refuel two vehicles at a time, based on the squadron operations areas used in the model. Aircraft must also have external fuel tanks to be refueled at the hotpit. If either of these conditions are not met, the aircraft taxi to the ramp to be refueled later. Aircraft that are refueled by the fuel trucks have an equal probability of changing their external fuel tank configuration. This is to simulate the scheduling of aircraft for a mission that either requires or does not require the use of the external fuel tanks.

The missiles used in this model are the AIM-9 or AIM-7 missiles. This again is to simulate the scheduling of aircraft for different missions. The AIM-9 is for air-to-air, and the AIM-7 is for air-to-ground. After the aircraft has its missiles uploaded, a preflight inspection is performed to check all preceeding tasks and ensure the aircraft is ready for take-off.

The movement of aircraft on the ground is a function

of the airfield layout used. In this model a standardized ramp is assumed for the parking of aircraft as shown in Figure 2. The times to taxi the aircraft and drive the fuel trucks are derived from studies conducted at Ramstein Air Base, Germany, and will be given in the parametric model. The TABVEE shelter that the aircraft are backed into is diagrammed in Figure 3; as shown, all necessary ordinance and equipment is available in the shelter, with the exception of the fuel truck.

The task times as given in The F-4E Aircraft Maintenance Support General Job Standards, are for operations in a wartime surge, but does not include the effects of personnel operating in a chemical environment. To account for this, the times were adjusted upwards for the wearing of chemically protective garments by use of the PDGRAM model (Ref.27).

The aircraft flight time used in this model is an exponential distribution with a mean of 70 minutes. The 70 minute mean time is approximately the flight time of an F-4 aircraft without air refueling. The reason for the use of an exponential distribution was to ensure the aircraft did not have negative flight times and to skew the majority of flight toward the low side of this mean. This is to simulate the proximity of a majority of the targets to be hit and areas defended by the aircraft. The probab-

ility of a flight lasting less than 50 minutes, using the distributions established, is approximately .5.

All activities for aircraft movement and operations on the ground are considered to have lognormal distributions. This is the type distribution the data best fits from the actual studies conducted and used in TAC modeling. The parameters used in the model are presented in Table III.

The times to complete each task are used not only in the calculations of the time to turn an aircraft, but also in the heat build-up values. Heat build-up is the result of heat generated and not dissipated by the individuals while wearing a non-permeable chemical defense ensemble. Each task demands a different work load, and these differing work loads determine the heat generated by the individual. Under normal conditions this heat would be dissipated into the atmosphere to help regulate the individuals body core temperature. While wearing the chemical defense ensemble, this dissipation effect is greatly reduced, so heat stress becomes a factor. These values are listed in Table IV as functions of Kilocalories (KCal).

A value of 70 KCal of heat build-up is used as a maximum allowable level in this model, to preclude heat stress. If an individual reaches this value, he is required to rest until this value is reduced to 30 KCal of heat build-up. For ease of computation, the level of heat

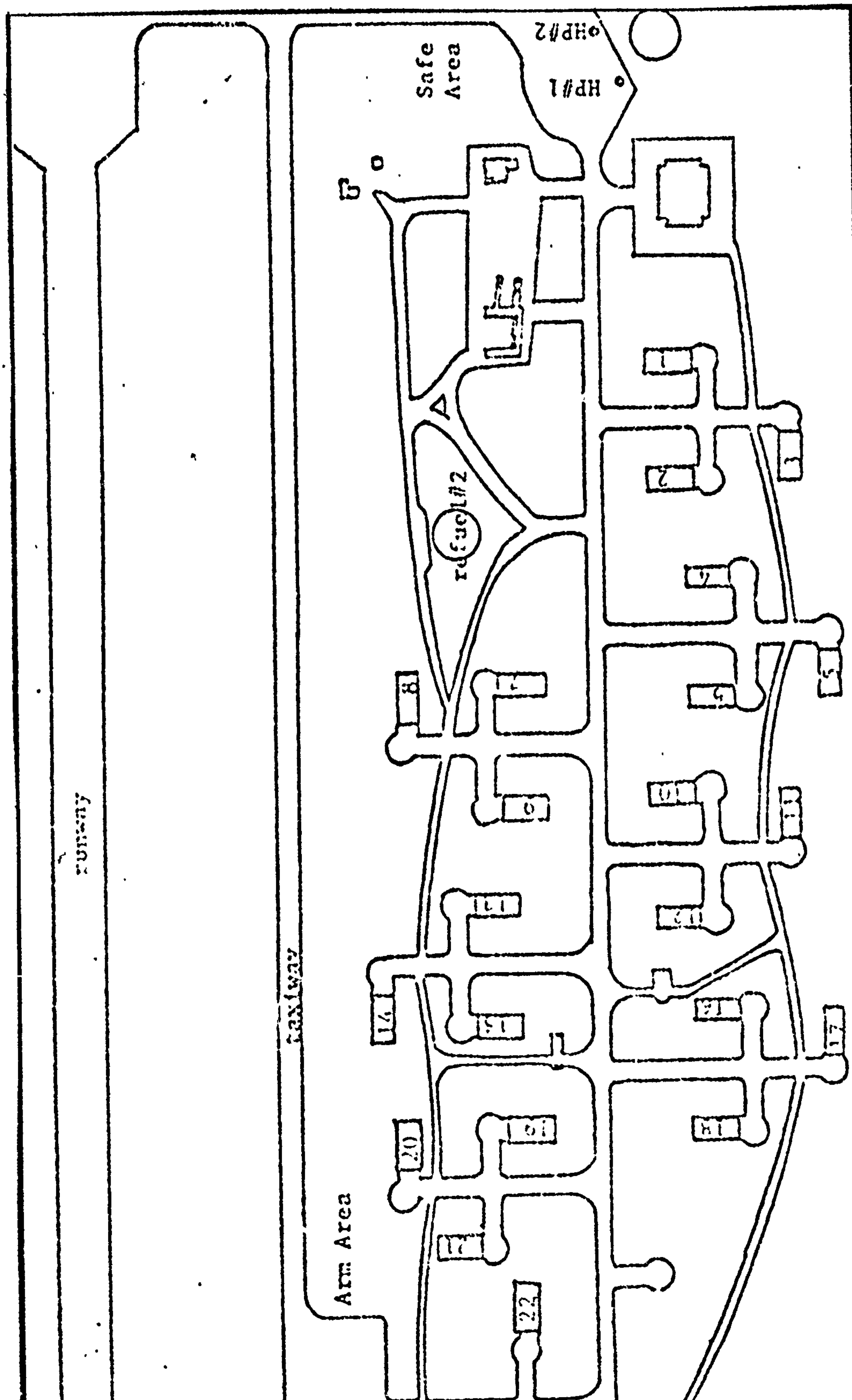

Fig. 2 Squadron Operations Area

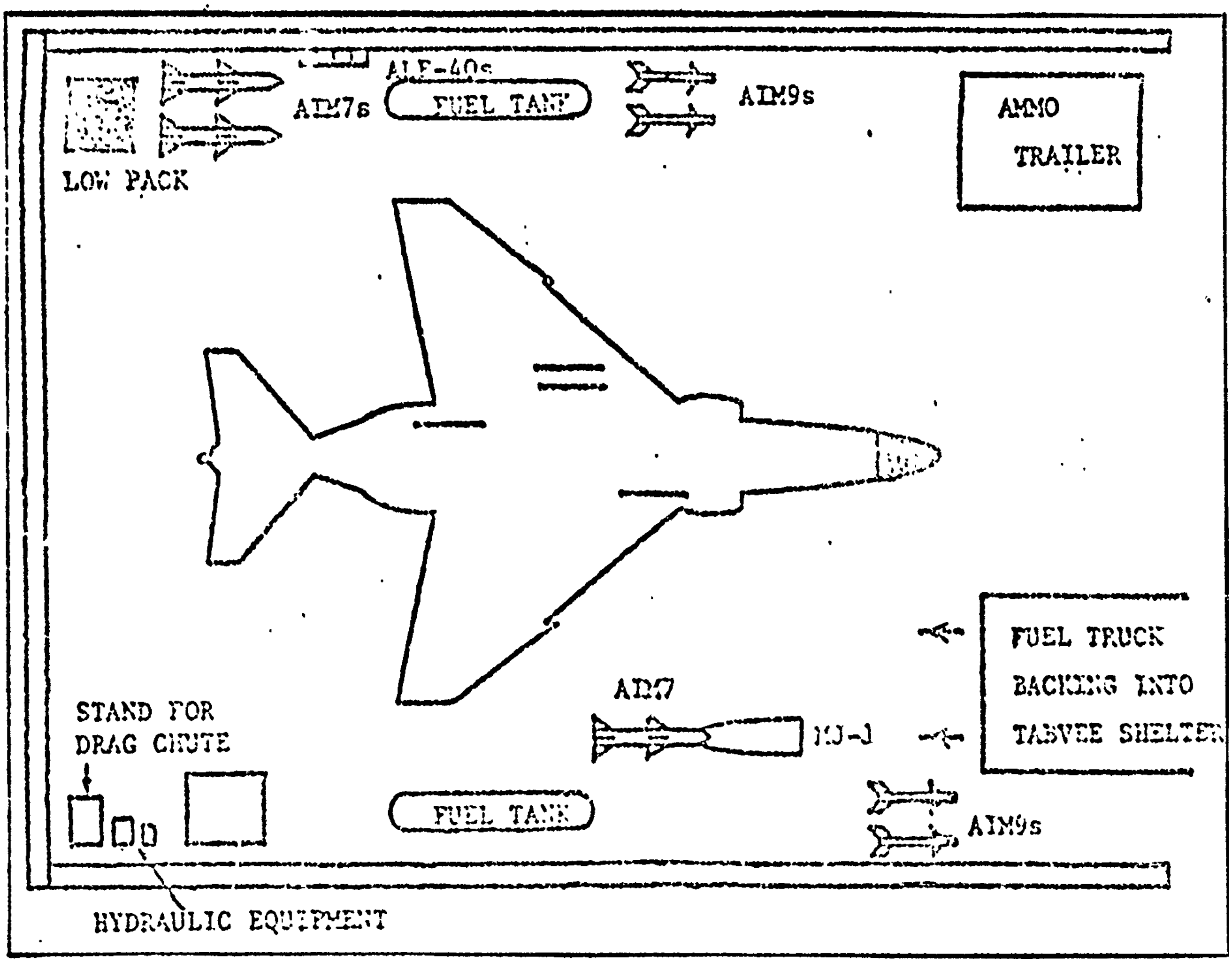

Fig. 3 TABVEE Shelter

Table III

PARAMETRIC MODEL

Event	Type Distribution	Mean	St.Dev.	Range
Flight	Exponential	70.00		0.00- 140.00
Taxi to Hotpit	Lognormal	2.19	0.10	2.00- 2.50
Hotpit Refueling	Lognormal	14.40	1.50	8.42- 18.98
Taxi to Shelter	Lognormal	3.50	0.70	1.80- 12.98
Aircraft Tow	Lognormal	4.70	0.60	3.00- 6.76
Aero 7 Inspection	Lognormal	1.15	0.15	0.73- 1.65
Reload Guns	Lognormal	10.80	1.30	6.89- 15.53
Change External Tank Configuration	Lognormal	16.80	2.00	10.72- 24.15
Missile Upload	Lognormal	31.25	2.80	19.94- 44.94
Preflight	Lognormal	5.90	0.60	3.77- 8.49
Fueling	Lognormal	16.80	2.00	10.72- 24.15
Drive Fuel Truck to Hotpit	Lognormal	2.00	0.30	0.95- 3.03
Drive Fuel Truck to Fuel Dump	Constant	27.00		

Table IV

HEAT BUILD-UP FACTORS (IN KCAL)

Task	Heat Generated (per minute)	Heat Dissipation (per minute)	Heat Build-up (per minute)
Aero 7 Inspection	2.30	0.83	1.47
Reload of Guns	2.80	0.83	1.97
External Fuel Tanks	2.30	0.83	1.47
Missile Upload	3.30	0.83	2.47
Preflight	1.30	0.83	0.47
Refueling or Rest	0.00	0.83	-0.83

Table V

PERCENTAGE HEAT CASUALTIES AS A FUNCTION OF BODY TEMPERATURE

Body Temp C	Body Temp F	Percentage Casualties
37.78	100	0.0
38.33	101	0.0
38.89	102	18.6
39.44	103	38.6
40.00	104	58.9
40.55	105	78.2
41.11	106	99.2
41.67	107	100.0

build-up is calculated for the completion of the task that is started. If 70 KCal is exceeded a rest period is enforced prior to the start of the next task. Each rest period is 48.19 minutes, the time to reduce 70 KCal to 30 KCal at the heat build-up rate for rest.

The effect of heat build-up on an individual is shown in Table V. A heat build-up of KCal corresponds to increasing the body internal temperature by approximately one degree fahrenheit. As can be seen from Table V, if this level is exceeded, casualities result among the maintenance personnel wearing the chemical defense ensemble.

The input parameters are not completely validatable, due to the inclusion of the effects of the chemical defense ensembles. The effects of increased time required, and the forced rest pericds are from controlled field test, laboratory experiments, and simulation modeling. Until actual data is available from a chemical attack upon an airfield these effects will be speculative.

Model Development

A network flow of events was developed to incorporate the tasks presented in the experimental design with the remaining activities of the causal loop diagram. The Q-GERT simulation language, with its basic form being a network diagram, was selected for use to create the simulation model.

The capability of Q-GERT to branch within the network, both probablisticly and deterministicly, simplified computerization. Queues, to restrict movement and hold transactions, were necessary to model refueling and the assignment of maintenance teams to aircraft.

A network was established to model the different phases of aircraft generations, as described in the next section of this thesis, and these networks were verified to perform as desired. These networks were then linked together to create a flow network for the entire model. Verification of the flow was checked as each smaller network was added. The network capabilities of Q-GERT were not sufficient for the creation of the finalized model with out the incorporation of User Subroutines (US). This allows the modeling of events in Fortran that can be called upon in the network. To simulate tasks with only the Q-GERT program would be difficult and cumbersome. In the finalized model, 16 user defined subroutines were used. These were used to simulate the performance of the maintenance tasks, the placement of aircraft into the different phases of operation, and for bookkeeping.

The User Subroutines (US) of the model are not given in the model description that follows, but are fully described in the program listing of Appendix C. By reference to the flow diagrams, the description of the tasks simula-

ted, and the program listing, an understanding of the model and its uses can be gained.

Model Description

The explanation of the simulation model shall be described in a segmented method, divided into its primary functions. A flow network will be given, followed by a description of the primary tasks performed in that section.

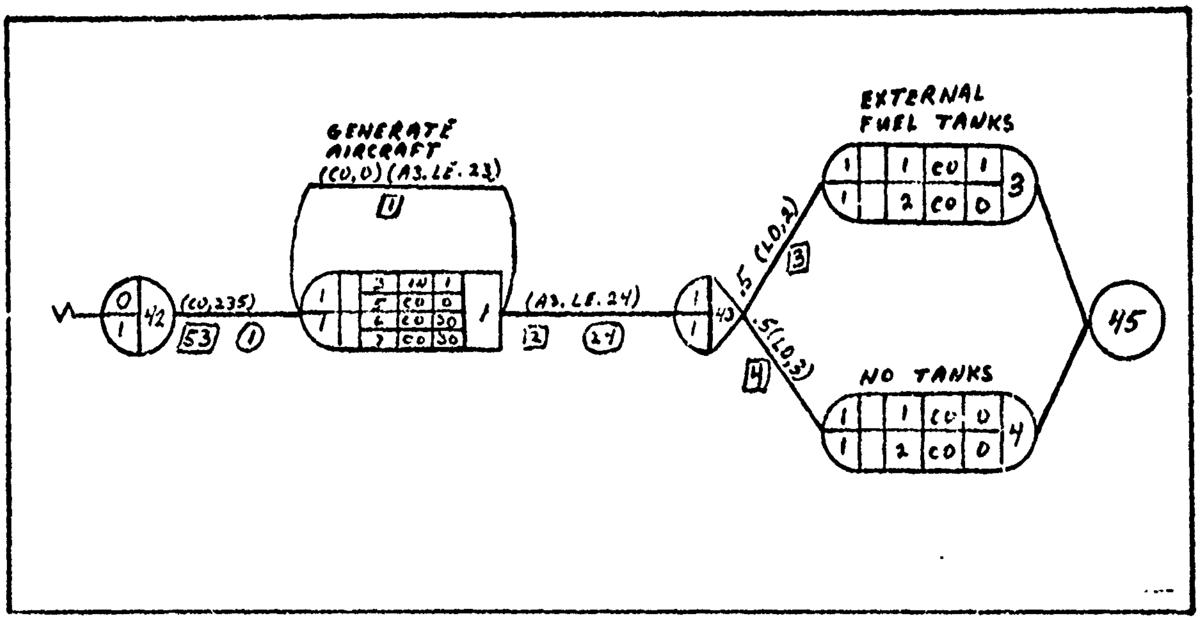

Fig. 4 Model Start

This portion of the model sets up the starting conditions of the aircraft and maintenance teams used in the model. Each aircraft is considered a transaction. By monitoring their values, the number of aircraft generated,

and a feel for the number of sorties flown during one day are calculated. A list of the variables assigned to the attributes of the model are as follows:

Attribute	Function
1	External fuel tank status
2	Fuel status
3	Aircraft number
4	Maintenance team number
5	Vehicle (aircraft or fuel truck)
6	Heat build-up on Maint teams
7	Heat build-up on Arming teams

Each of the aircraft are considered to be flyable for the first launch of the day, which occurs 235 minutes after attack of the field, the start of the model. This delay is incorporated to account for recall of the aircrew and maintenance personnel, issuance and donning of the chemical defense ensembles, initial briefings to the aircrews, and preflight of the aircraft.

The number of aircraft available at the airfield can vary from one to fifty and is set in Activities 1 and 2, with the incrementation of Attribute 3. The aircraft are uniformly distributed as to the status of external fuel tanks and are all considered fueled. As the aircraft are readied for their first take-off of the day, they flow into the next segment of the model.

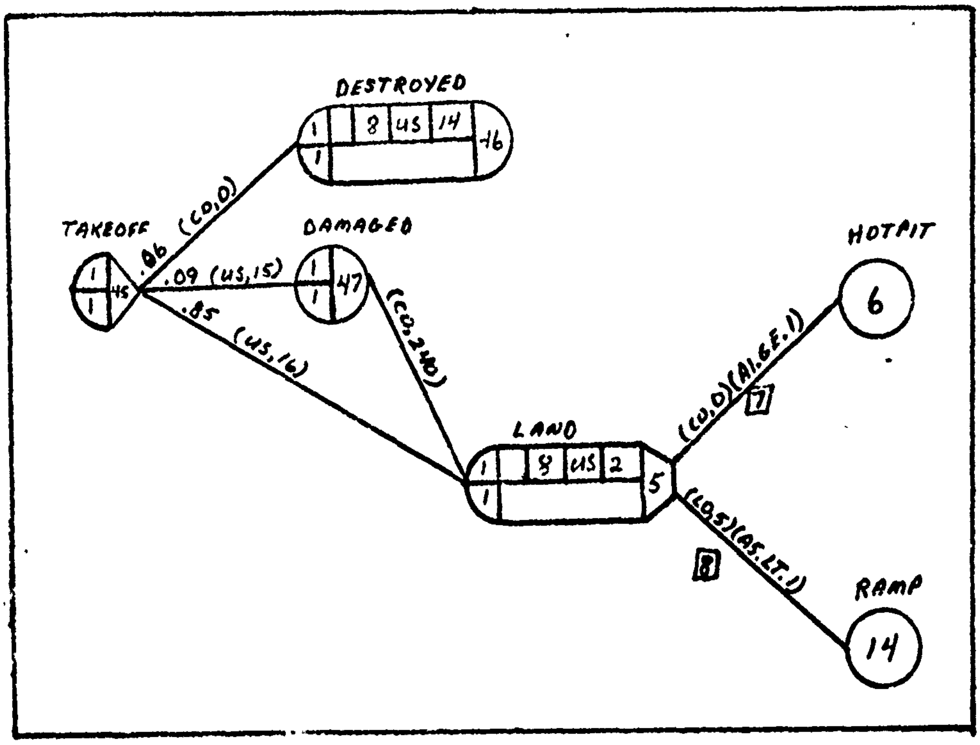

Fig. 5 Aircraft Flight

As aircraft take-off, three options are available, the aircraft can be destroyed, damaged, or fly without damage. The probabilities associated with each are controlled in the Q-GERT model, Activity 45, and are set at the values of 6% destroyed and 9% damaged. If an aircraft is destroyed it is removed from the model. If damaged, it incurs a 240 minute delay to simulate repair when it lands, and then re-enters the network at Node 5. Those aircraft that are not damaged, but have a flight time of less than 15 minutes, are considered air aborts. An air aborted aircraft is given a 240 minute delay, regardless of the cause of the air abort. It then re-enters the network at Node 5. The cause of the air abort is not modeled,

but would include both maintenance problems with the aircraft and physiological problems with the aircrew, which must also wear chemical defense ensembles. After landing, the aircraft either taxi to the hotpit for refueling or to its parking spot on the ramp. Analysis of the model will be performed on both the percentage of aircraft destroyed or damaged, the time to perform maintenance on the aircraft after it has been damaged or air aborted, and the abort rate.

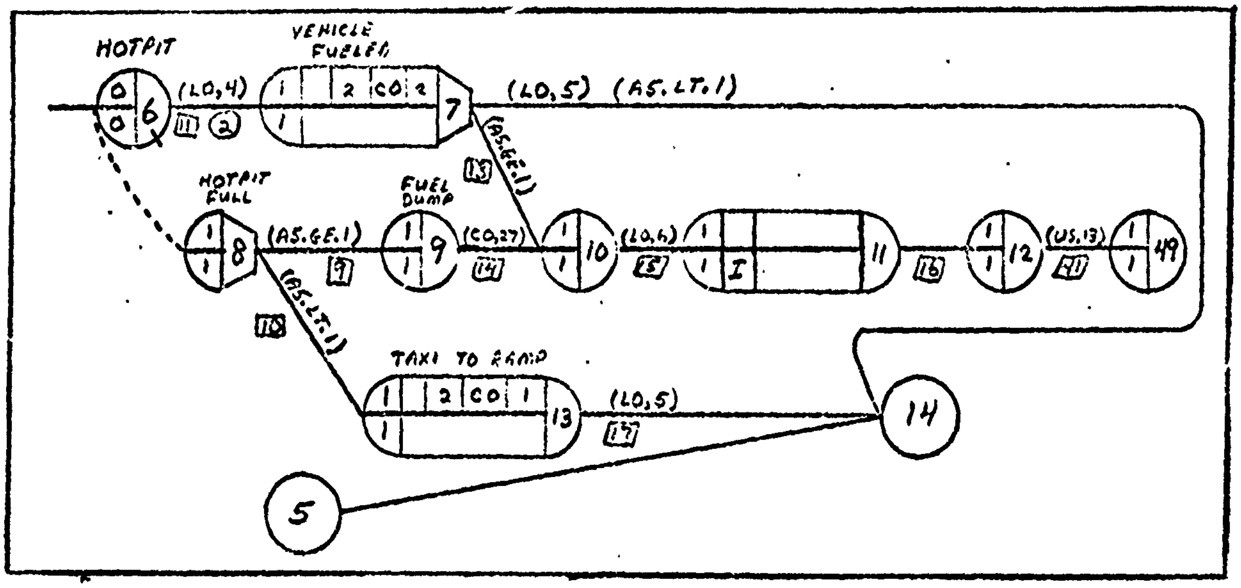

Fig. 6 Refueling

Refueling of the aircraft at the hotpit and refueling of the fuel trucks, that perform the remainder of the aircraft refueling, are diagrammed in Figure 6. Aircraft with external fuel tanks and the fuel trucks are the only vehicles that are fueled at the hotpit, which is limited to fueling only two vehicles at a time. If the hotpit is available, aircraft are refueled and then taxi to their parking spot on the ramp. If the hotpit is full, or the aircraft does not have external fuel tanks, it taxis to the ramp, and must be refueled later. Fuel trucks that are not fueled at the hotpit must drive to the fuel dump to be fueled prior to returning to the ramp to refuel aircraft.

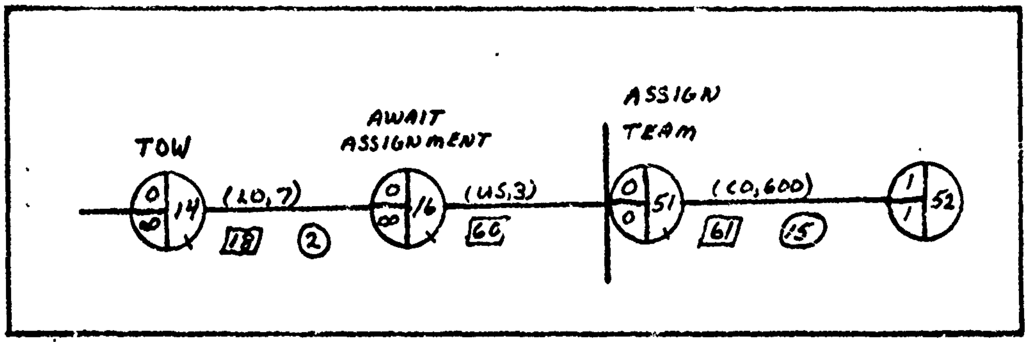

Fig. 7 Parking and Maintenance Assignment

After the aircraft have taxied to their parking spots, they must be backed into their TABVEE shelters. There are two tugs to perform this required function. Once the aircraft is parked, the times required to perform all the follow-on maintenance tasks are calculated (using User Subroutine 3). The heat build-up values are then calculated and the aircraft awaits assignment of a maintenance team. The number of maintenance teams available are fixed in Activity 61 where the number of servers is set to one less than the number of teams. This uses the blocking capabilities of Q-GERT to ensure an aircraft cannot be assigned to a maintenance team unless a team is available. Aircraft are not assigned unless a maintenance team is available, and is then assigned to the team that has worked on the least number of aircraft to that time.

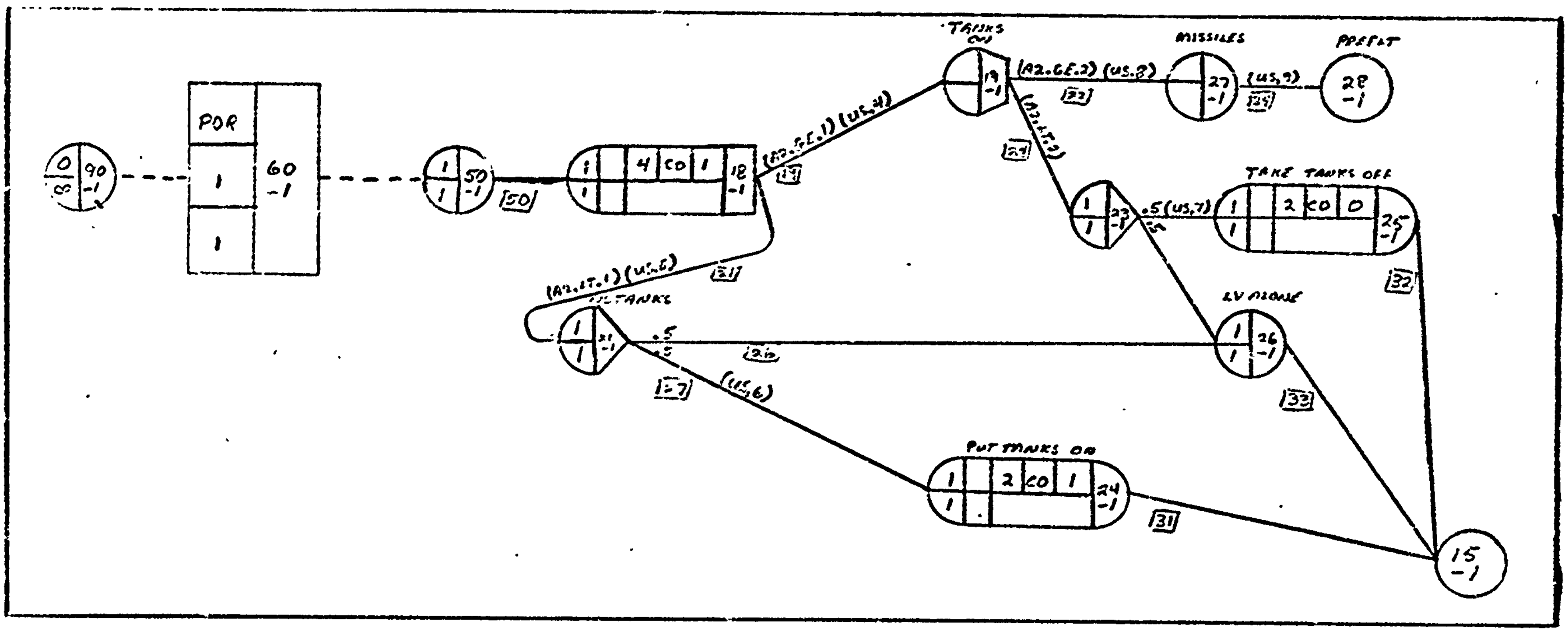

Fig. 8 Maintenance Subnetwork

Figure 8 is the flow network of one of the sixteen subnetworks in the model that performs all the required maintenance on the aircraft, except refueling. Each maintenance team is considered a resource and is monitored as such. This is to ensure that a maintenance team does not work more than one aircraft at a time. The status of the aircraft is checked according to fuel and external fuel tank status. To simulate scheduling of aircraft for differing missions, aircraft that have not been refueled have a probability of .5 of changing its external fuel tank configuration. All aircraft are given a postflight inspection, have their guns reloaded and missiles up-loaded, and a preflight inspection. Before aircraft can have the missiles up-loaded, they must be refueled. If they were fueled in the hotpit, they proceed from Node 19 to Node 27, missiles up-load, otherwise they proceed through the network to Node 15. Aircraft that proceed to Node 15 will await refueling and then re-enter the subnetwork at Node 27 and proceed. After an aircraft has all maintenance complete, it proceeds to take-off status.

The maintenance team is broken down into two teams, a maintenance team and an arming team. The maintenance team performs the inspections and aids the arming team, which work on the aircraft armament.

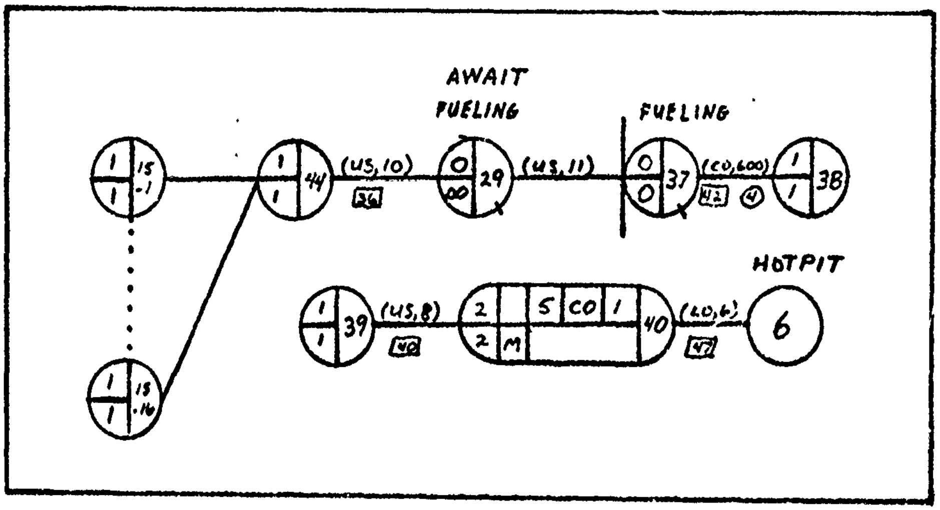

Fig. 9 Refueling by Fuel Truck

The refueling of aircraft by the fuel trucks is handled as a queueing system. The aircraft must wait until a fuel truck is available to refuel them, after refueling, they re-enter the subnetwork at Node 27. The time the aircraft must wait for refueling and the time required to refuel will reduce the thermal build-up on the maintenance teams. The reason for this is that a refueling team performs this function, rather than the maintenance team, so they can rest until refueling is complete. After the fuel truck had refueled two aircraft, it must be refueled. It drives to the hotpit, Node 6, and is either refueled or must drive to the fuel dump for refueling prior to returning to the ramp. Analysis was performed on the number of fuel trucks available. Results of the analysis will be presented in the next chapter.

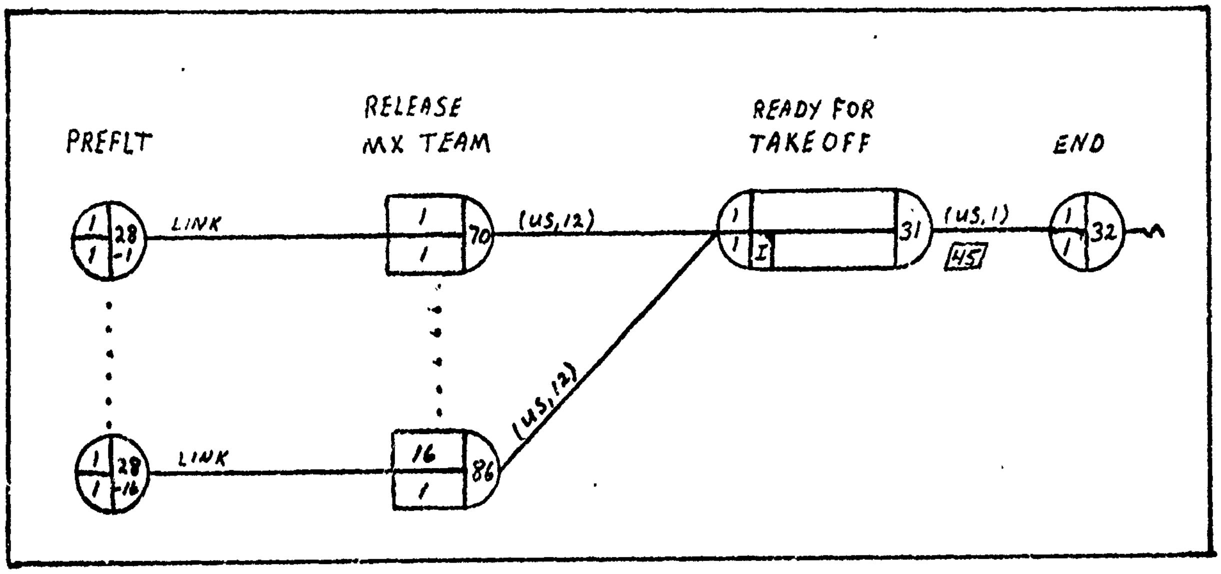

Fig. 10 Release Maintenance Teams

After all maintenance functions are performed on an aircraft, the maintenance team is made available for assignment to another aircraft. All artificial activities generated in the maintenance cycle for that team are halted and the aircraft must await a formation take-off. Each formation take-off consists of two aircraft, this is controlled in User Subroutine 1.

Summary

The simulation model, based on the assumptions and the required tasks necessary to generate aircraft, generates data points by varying the control variables. The model output includes data on the number of aircraft generated and sorties flown for differing levels of maintenance support and available aircraft. The model is cap-

able of producing this data for both a chemical and non-chemical environment, provided the physical resources of the air base are not damaged. To use this model in a conventional environment, the heat build-up factors are changed to zero. The times to perform the tasks are not increased due to the wearing of the ensemble, as they were in the parametric model.

III. Data Collection and Analysis

Introduction

The model was created to generate data to make comparisons between different levels of maintenance. A nonparametric test was used to make the comparisons. This test, the Friedman Test, is used to make comparisons over the entire range modeled, as well as between each individual level. The model output provides data on the number of aircraft generated and the number of sorties flown. Each run corresponds to the operations of an air base for one day. By varying the number of aircraft and maintenance teams available, the effects of change can be analized on the turn rate of the aircraft. To gain a better understanding of the implications of the input parameters, sensitivity analysis was performed. The areas covered are the abort rate and its associated maintenance delay, the amount of fuel trucks available, and the percentage of aircraft destroyed and damaged.

Data Collection

The program was run a total of 90 times to obtain two observations per cell. A typical fighter squadron has 24 aircraft and approximately 8 maintenance teams to support them, on an air base there is usually more

than one squadron of aircraft assigned. To measure the capabilities of the maintenance teams to perform in the chemical environment, the number of teams for which data was collected ranges from 8 to 16. To correspond with the number of teams available, the range of available aircraft vary from 24 to 48. This is to maintain the same ratio of aircraft to maintenance support. The two observations per cell are generated by holding all variables constant within that cell, and changing the random number seed. This is to ensure that the data is not biased due to the seed used.

Three sets of data were collected to measure the capabilities of the maintenance teams to support aircraft generation and sorties. The first of these is the number of aircraft generated after the first launch of the day. The second two deal with two methods of counting sorties flown. The first of these is counting all aircraft that take-off and land and the second is a reduction of this number by the amount of aircraft that air abort. Appendix D contains a portion of an output run to show the method of bookkeeping used in the model.

Data Analysis

The data was collected in such a manner as to make analysis of the effects of having different maintenance levels and numbers of aircraft possible. A nonparametric test was considered to measure the effects of operating

at these different levels. The test used is a Friedman's Test and its modification for multiple observations within a cell (Ref.4:299-308).

The Friedman Test is a nonparametric test to analize several related samples. It is used to detect differences between treatments. There are two assumptions that must hold to use this test: the observations must be able to be ranked, and the bk-variate random variables are mutually independant. This means the data need only be at an ordinal level and the data points in the set are mutually independant. The hypotheses to be tested are:

Ho : Each ranking of the random variables within a block is equally likely (i.e.,the treatments have identical effects).

Hi : At least one of the treatments tends to yield larger observed values than at least one other treatment.

The data is arranged into the following format:

Treatment

Block	1	2	...	k
1	X_{11}	X_{12}	...	X_{1k}
2	X_{21}	X_{22}	...	X_{2k}
...	...	...	...	...
b	X_{b1}	X_{b2}	...	X_{bk}

where there are 'k' treatments and 'b' blocks. Each data point is then ranked within the block over the different treatments. These ranked values are designated as $R(X_{ij})$, treatments. The sum of the ranks within the treatments

is designated R_j.

The following three equations must be solved and then a decision rule applied. A_2 and B_2 are intermediate values needed to arrive at the test statistic T_2.

$$A_2 = \sum_{i=1}^{b} \sum_{j=1}^{k} \left[R(X_{ij})\right]^2$$

$$B_2 = \frac{1}{b} \sum_{j=1}^{k} R_j^{\,2}$$

$$T_2 = \frac{(b-1)(B_2 - bk(k+1)^2/4)}{A_2 - B_2}$$

where: $R(X_{ij})$ = ranked values
b = number of blocks
k = number of treatments

The decision rule that is applied is to reject the null hypothesis at the desired α level if T_2 exceeds the $1-\alpha$ quantile of the tabled F distribution. The degrees of freedom are given by $k_1=k-1$ and $k_2=(b-1)(k-1)$. The F distribution approximates the exact distribution of T_2.

If multiple comparisons between the treatments are to be performed, as they are in this thesis, the following equation is used:

$$\left|R_j - R_i\right| > t_{1-\alpha/2} \left[\frac{2b(A_2-B_2)}{(b-1)(k-1)}\right]^{\frac{1}{2}}$$

The values of $t_{1-\alpha/2}$ is the $1-\alpha/2$ quantile of the t distribution with $(b-1)(k-1)$ degrees of freedom. The same level used for checking the entire range, T_2, must be used.

When there are several observations per experimental cell, the test is only slightly modified. The only parameter not previously defined is 'm', the number of observations in each cell.

The mean of R_j becomes:

$$E(R_j) = \sum_{i=1}^{b} \sum_{n=1}^{m} E\left[R(X_{ijn})\right]$$

$$= \frac{bm(mk+1)}{2}$$

The variance of R_j is given by:

$$\mathrm{Var}(R_j) = \frac{m(k-1)}{k(mk-1)} \left[\sum_{\substack{\text{all}\\ \text{ranks}}} R(X_{ijn})^2 - mkb(mk+1)^2/4\right]$$

The test statistic is:

$$T_4 = \sum_{j=1}^{k} \frac{(k-1)}{k} \frac{\left[R_j - E(R_j)\right]^2}{\mathrm{Var}(R_j)}$$

This is tested against a chi-squared distribution with k-1 degrees of freedom. The null hypothesis is rejected if the value of T_4 exceeds the tabled chi-square value.

To make multiple comparisons, the below equation is solved, where $t_{1-\alpha/2}$ is the $1-\alpha/2$ quantile of the t distribution with (mbk-k-b+1) degrees of freedom.

$$\left|R_j - R_i\right| > t_{1-\alpha/2} \left\{\frac{2kb(mk-1)\mathrm{Var}(R_j)}{(k-1)(mbk-k-b+1)} \left[1 - \frac{T_4}{b(mk-1)}\right]\right\}^{\frac{1}{2}}$$

The results of the test used for comparisons between the individual treatments are more significant to this thesis than the test over the entire range. This data is used to check for significant differences differences between the individual treatments. If the analysis indicates that 10 maintenance teams are required to meet a desired turn rate, and there is not a significant difference between having 9 or 10 teams, then having 9 teams is sufficient.

The test is run twice, once using the maintenance teams as the treatments, and then using the aircraft as the treatments. This was done to ensure that the different levels of maintenance were causing the changes in turn rate, not just the change in the number of aircraft available.

This test can be used without knowing the exact distribution of the data points to be analized. The assumptions to perform a similar test in the realm of parametric statistics, the two-way analysis of variance, (ANOVA), could not be met with the collected data. If the assumptions are not met, the results are questionable. The results of the two-way ANOVA are highly sensitive to the non-homogeneity of variances among the data set. If the variances are unequal it will result in significant differences even if the means of the treatments are the same.

A Bartletts Test was run on the data for generated aircraft, to check for homogeneity of variance, and it failed (Ref. 19:325).

Aircraft Generation. The number of aircraft generated by maintenance during the one day operation does not include the first launches of the day for the aircraft. The reason for this is that all aircraft are considered flyable at the start of the day, with all maintenance complete. To avoid bias in the data caused by the random number stream, two observations were taken for each cell. This raw data, Table VI, was then converted to ranks, according to the proceedures of the Friedman Test, and comparisons were made on the effects of varying the number of aircraft and maintenance teams. Table VII was used to measure the effects of increasing the number of aircraft at the different maintenance levels. Table VIII measures the effects of increasing maintenance personnel at the various levels of available aircraft.

In both cases the test results indicate a difference between the treatments throughout the ranges of the blocks. In Table VII, the aircraft were considered the treatments, and in Table VIII, the maintenance teams. By making comparisons between the treatments of each table, it was shown that there was not a significant difference between starting with 36 or 42 aircraft, and not a difference be-

tween starting with 13 or 14 maintenance teams. All other comparisons showed a significant difference. Appendix F contains the results of the tests.

TABLE VI

RAW DATA ON THE NUMBER OF
AIRCRAFT GENERATED BY MAINTENANCE
AT VARIOUS LEVELS OF
MAINTENANCE AND AIRCRAFT

# of Aircraft	# of Maintenance Teams								
	8	9	10	11	12	13	14	15	16
24	49	53	56	57	58	69	70	71	71
	50	50	53	67	65	67	62	59	66
30	47	57	59	63	67	73	72	80	80
	51	57	64	67	71	76	78	74	76
36	53	57	64	69	74	81	85	91	92
	49	56	62	67	74	80	86	86	91
42	50	56	63	65	73	76	85	90	93
	52	58	64	69	77	83	87	90	94
48	51	58	64	69	75	80	86	90	95
	54	58	62	70	75	80	87	94	97

TABLE VII

RANKED DATA ON THE
NUMBER OF AIRCRAFT GENERATED
BY MAINTENANCE
CHECKING FOR DIFFERENCES IN
MAINTENANCE LEVELS

		#of Aircraft (Treatments)				
		24	30	36	42	48
# of Mx Teams	8	2.5	1	9	4.5	6.5
		4.5	6.5	2.5	8	10
	9	2	6	6	3.5	9
		1	6	3.5	9	9
	10	2	3	8.5	6	8.5
		1	8.5	4.5	8.5	4.5
	11	1	2	8	3	8
		5	5	5	8	10
	12	1	3	6.5	5	8.5
		2	4	6.5	10	8.5
	13	1	3	9	4.5	7
		2	4.5	7	10	7
	14	2	3	5.5	5.5	7.5
		1	4	7.5	9.5	9.5
	15	2	4	9	7	7
		1	3	5	7	10
	16	2	4	6	7	9
		1	3	5	8	10
	R_j	34	73.5	114	124	149.5

TABLE VIII

RANKED DATA ON THE
NUMBER OF AIRCRAFT GENERATED
BY MAINTENANCE
CHECKING FOR DIFFERENCES IN
MAINTENANCE LEVELS

# of Aircraft	# of Maintenance Teams (Treatments)								
	8	9	10	11	12	13	14	15	16
24	1	4.5	6	7	8	15	16	17.5	17.5
	2.5	2.5	4.5	13.5	11	13.5	10	9	12
30	1	3.5	5	6	8.5	12	11	17.5	17.5
	2	3.5	7	8.5	10	14.5	16	13	14.5
36	2	4	6	8	9.5	12	13	16.5	18
	1	3	5	7	9.5	11	14.5	14.5	16.5
42	1	3	5	7	9	10	13	15.5	17
	2	4	6	8	11	12	14	15.5	18
48	1	3.5	6	7	9.5	11.5	13	15	17
	2	3.5	5	8	9.5	11.5	14	16	18
R_j	14.5	35	55.5	80	95.5	123	134.5	150	166

Aircraft Sorties. Table IX portrays the data on the number of sorties flown for the different levels of aircraft and maintenance teams. The definitions of sorties flown for this data includes all aircraft that take-off and land, including the first launches of the day. Those aircraft that are destroyed are not included as sorties. The measurement was taken in this manner to see the effects on the maintenance teams when aircraft are destroyed and removed from the system. Again tests were run using both the number of aircraft and the number of maintenance teams available as treatments in the modified Friedman's Test. In both cases the test revealed there was a difference between the treatments.

The data using the numbers of aircraft as the treatments is presented in Table X. In the comparisons, there were no two treatments that were not different. This differs from the results of Table VII on the maintenance generated aircraft. The reason for this is that now the first launches of the aircraft are included.

Table XI contains the data to run the test using the maintenance teams as the treatments. Although the test revealed a difference between the treatments, when comparisons were made between the individual treatments, in all cases but one, it showed that there was not significant differences between the adjoining treatments.

This indicates that when increasing the maintenance teams available by one, except between 12 and 13 teams, there is no appreciable difference. Having ten maintenance teams does not significantly increase the number of sorties flown over having only nine teams, but is quite better than having only eight teams. Appendix F contains the results of the tests.

TABLE IX

RAW DATA ON THE
NUMBER OF SORTIES FLOWN

	# of Maintenance Teams								
# of Aircraft	8	9	10	11	12	13	14	15	16
24	65	71	71	67	64	81	84	82	78
	64	64	63	75	77	77	72	69	75
30	65	68	78	80	82	85	84	95	93
	72	72	77	78	86	86	94	86	89
36	83	82	89	91	94	103	106	107	114
	71	76	86	89	91	99	99	101	112
42	82	82	94	95	98	95	111	117	111
	81	89	93	92	95	102	112	112	118
48	93	97	97	104	109	108	119	108	130
	82	90	94	99	105	109	112	119	119

TABLE X

RANKED DATA ON THE NUMBER OF SORTIES FLOWN CHECKING FOR DIFFERENCES IN AIRCRAFT LEVELS

# of Mx Teams	# of Aircraft (Treatments) 24	30	36	42	48
8	2.5	2.5	9	7.5	10
	1	5	4	6	7.5
9	3	2	6.5	6.5	10
	1	4	5	8	9
10	2	4	6	8.5	10
	1	3	5	7	8.5
11	1	4	6	8	10
	2	3	5	7	9
12	1	3	6	8	10
	2	4	5	7	9
13	2	3	8	5	9
	1	4	6	7	10
14	2.5	2.5	6	7	10
	1	4	5	8.5	8.5
15	2	4	6	8	9
	1	3	5	7	10
16	2	4	7	5	10
	1	3	6	8	9
R_j	29	62	106.5	129	168.5

TABLE XI

RANKED DATA ON THE
NUMBER OF SORTIES FLOWN
CHECKING FOR DIFFERENCES IN
MAINTENANCE LEVELS

		# of Maintenance Teams (Treatments)								
		8	9	10	11	12	13	14	15	16
# of Aircraft	24	5	8.5	8.5	6	3	16	18	17	15
		3	3	1	11.5	13.5	13.5	10	7	11.5
	30	1	2	6.5	8	9	11	10	18	16
		3.5	3.5	5	6.5	13	13	17	13	15
	36	4	3	6.5	8.5	10	14	15	16	18
		1	2	5	6.5	8.5	11.5	11.5	13	17
	42	2.5	2.5	7	9	11	9	14.5	16.5	14.5
		1	4	6	5	9	12	16.5	13	18
	48	4	5.5	5.5	8	11.5	10	16	14	18
		1	2	3	7	9	11.5	13	16	16
	R_j	26	36	54	76	97.5	121.5	141.5	143.5	159

When the number of sorties flown is reduced by the number of air aborts, using the same definition of sorties flown as before, the number of flights is reduced. Table XII contains the data on the number of these flights. By comparing this data with that contained in Table IX, the result of not counting air aborts as sorties can be seen. As more aircraft are made available for flight, the number of aircraft that air abort increases, although the percentage of air aborts is fixed. This fact must be remembered when trying to increase the number of sorties flown by increasing the number of aircraft available to fly.

TABLE XII

RAW DATA ON THE
NUMBER OF SORTIES
REDUCED BY AIR ABORTS

	# of Maintenance Teams								
# of Aircraft	8	9	10	11	12	13	14	15	16
24	51	58	55	51	49	63	66	69	61
	54	52	49	65	62	65	61	54	65
30	54	52	59	66	61	66	71	79	69
	57	55	61	64	75	66	79	72	67
36	63	69	66	63	74	82	87	83	90
	58	64	78	74	83	83	84	92	97
42	62	65	74	78	71	75	88	87	86
	73	76	80	78	79	83	95	93	93
48	80	83	79	86	89	84	96	95	111
	62	76	78	81	86	89	85	99	99

Turn Rate. The turn rate on aircraft is one of the usual ways at looking at data dealing with maintenance and aircraft generation. The turn rate is arrived at by adding the number of aircraft available to those generated in the one day scenario, and then dividing by the number of aircraft available at the start of the day. The data presented in Table XIII shows the breakdown of this statistic over the differing levels of maintenance teams and aircraft modeled. Comparisons can be made between this table and the desired turn rate of a theater commander. For example, the Quest document stated this desired turn rate at 3.22. By looking at the table, this corresponds to having ten maintenance teams for 24 aircraft, or approximately one team for every 2.5 aircraft. This ratio is also seen at the different levels of avialable aircraft modeled. By knowing the desired turn rate, a ratio of maintenance personnel to aircraft can be established.

Remembering that turn rate is based on the number of aircraft that are capable of flying, the results of the tests run on maintenance generated aircraft is used. This showed that each level of maintenance is significantly different from the others, except between 13 and 14 teams available.

Sensitivity Analysis

Sensitivity analysis was performed on several of the

TABLE XIII

TURN RATE OF AIRCRAFT

# of Aircraft	# of Maintenance Teams								
	8	9	10	11	12	13	14	15	16
24	3.0625	3.1458	3.2708	3.5625	3.5625	3.8333	3.7500	3.7083	3.8542
30	2.6333	2.9000	3.0500	3.1667	3.3000	3.5833	3.5000	3.5667	3.6000
36	2.4167	2.5690	2.7500	2.8889	3.0556	3.2361	3.3750	3.4583	3.5417
42	2.2140	2.3571	2.5119	2.5952	2.7857	2.8929	3.0476	3.1429	3.2262
48	2.0938	2.2083	2.3125	2.4479	2.5625	2.6667	2.8021	2.9167	3.000

variables to measure the effects that changes in their values have on the results of the model output. The reason for this type analysis is to measure which variables have a significant effect on the output. The items checked in this thesis are an item that could be changed in the operations, the number of fuel trucks, and the variables that decrease the number of sorties flown. These items are the air abort rate, the maintenance delay on air aborted aircraft, and the percentage of aircraft destroyed and damaged.

The times to complete the individual tasks and the effects of heat build-up were not considered for follow-on analysis. These areas are not well established and are, therefore, used only as comparitive factors for analysis between the ranges of aircraft and maintenance teams available. Due to the nature of the model, a summing of the tasks performed, an increase or decrease in the maintenance task times would cause an inverse result in the number of aircraft that could be generated. The heat build-up level and factors used to change the task times would have the same type results. The first area presented is the air abort rate.

Air Abort Rate. The air abort rate is set in US 16. The flight time is an exponential distribution, and by setting a limit on aircraft by flight time, a percentage of aircraft are termed air aborts. By varying the time

limit for air abort flights, the number of aircraft available for maintenance generation and follow-on sorties is varied. In the main model a flight time less than 15 minutes is considered an air abort, this works out to approximately 19 percent of all flights terminating in air aborts.

With the flight time an exponential with a mean of 70 minutes, the probability of a flight less than the one designated as an air abort is given by:

$$P(T<x) = 1-e^{-x/70}$$

For a cut-off set at 10 minutes, approximately 13 percent of all aircraft air abort, and for 5 minutes the air abort rate is only 7 percent. As shown in Table XIV, the value used to set the air abort rate is more noticable when there are less aircraft available on the number of sorties flown. The prime factor limiting the number of aircraft flown is the number of aircraft. As the number of aircraft increase, the abort rate is not as important, because the maintenance teams are constantly working or in forced rest periods. At the range of personnel to aircraft recommended in the turn rate analysis, of 2.5 aircraft per team, the air abort rate is significant on the number of aircraft flown, but not on the capability to generate aircraft. As the turn rate is based on the capability to fly aircraft, not actual flights, the abort rate used does not greatly change the turn rate.

Maintenance Delay on Aborted Aircraft. Maintenance delays are primarily a factor of the maintenance team's ability to analize the problem with the aircraft and then correct the problem. When wearing the chemical defense ensemble, several senses of the personnel are limited. The obvious restrictions of visibility and reduced dexterity are further hampered by the removal of the sense of smell. Electronic sniffers must be used to aid in checking for fuel and hydralic leaks. Only two sets of runs were made on this factor. The maintenance delay used in the model is 240 minutes. This delay is added to the time the aircraft must spend going through the maintenance cycle again. The delay of zero time added to the time required by going through the maintenance cycle was used for comparison. A similar trend to that shown in the air abort rate section presented above, is repeated. By reducing the delay, an increase in both the number of sorties flown and aircraft generated is realized. This increase is of less significance when the number of aircraft to teams approaches the 2.5 level proposed in the turn rate analysis. As these delays are modeled in this thesis, maintenance delays do not greatly effect the turn rate at the 2.5 to 1 ratio recommended. Table XV presents this information.

TABLE XIV

RESULTS OF VARYING THE
AIR ABORT RATE
ON THE NUMBER OF AIRCRAFT GENERATED
AND FLOWN AT VARIOUS AIRCRAFT LEVELS
WITH 16 MAINTENANCE TEAMS

		Maintenance Generated Aircraft Flight Time for Air Aborts			
		0	5	10	15
	24	85	74	73	73
Number	30	90	79	78	81
of	36	99	96	91	92
Aircraft	42	93	98	93	94
	48	98	95	100	99

		Number of Sorties Reduced by the Number of Air Aborts Flight Time for Air Aborts			
		0	5	10	15
	24	96	77	70	68
Number	30	106	90	80	79
of	36	119	106	94	92
Aircraft	42	121	105	96	96
	48	130	106	116	107

TABLE XV

EFFECTS OF VARYING THE TIME DELAY FOR AIR ABORTED AIRCRAFT AT VARIOUS AIRCRAFT LEVELS WITH 16 MAINTENANCE TEAMS

		Maintenance Generated Aircraft		
		Time Delay		Percent Increase
		240.0	0.0	
	24	71	85	19.7
Number	30	80	90	12.5
of	36	92	99	7.6
Aircraft	42	93	93	0.0
	48	95	98	3.2
		Number of Sorties Flown		
		Time Delay		Percent Increase
		240.0	0.0	
	24	78	96	23.1
Number	30	93	106	14.0
of	36	114	119	4.4
Aircraft	42	111	121	9.0
	48	130	130	0.0

Aircraft Destroyed and Damaged. Table XVI shows the effect of varying the percentage of aircraft destroyed and damaged. The model parameters were increased to 0.1 and 0.2 respectively. It is important to remember that destroyed aircraft are not considered as sorties flown for this data. By increasing the percentage of aircraft that receive little damage, a decrease in the number of aircraft generated and flown would be realized. This decrease would result in a decrease in the turn rate over all ranges of aircraft and maintenance. The percentage of little damaged aircraft is a function of the aircrew members wearing the chemical defense ensemble. It is for this reason that research is being performed at reducing the need for the full chemical defense ensemble to be worn in the aircraft. Appendix B contains material on the environmental control system for the aircraft.

Fuel Trucks. The final areas of sensitivity analysis deals with the number of fuel trucks available, Table XVII. It would seem reasonable to assume that if more fuel trucks were available, the aircraft turn rate would be higher. This, however, is not the case. The primary restriction on the maintenance teams is the heat build-up level. With a limited number of fuel trucks, the aircraft must spend more time awaiting refueling, allowing the teams to rest. When the number of trucks increases, the aircraft are re-

fueled quicker, but the teams are forced to rest at a later time to reduce their heat build-up, which off-sets any benefit of increased fuel trucks. There is not any benefit of increased fuel trucks. There is not any benefit to increasing the number of fuel trucks at the ranges of aircraft and personnel modeled.

TABLE XVI

EFFECTS OF VARYING THE PERCENTAGE OF DESTROYED AND DAMAGED AIRCRAFT AT VARIOUS AIRCRAFT LEVELS WITH 16 MAINTENANCE TEAMS

	Maintenance Generated Aircraft			
	Destroyed / Damaged	0.06 / 0.09	0.1 / 0.2	Percent Decrease
	24	68.5	53	22.6
Number	30	78	65	16.7
of	36	91.5	80.5	12.0
Aircraft	42	93.5	86	8.0
	48	96	93	3.0
	Number of Sorties Flown			
	Destroyed / Damaged	0.06 / 0.09	0.1 / 0.2	Percent Decrease
	24	76.5	62.5	18.3
Number	30	91	78	14.3
of	36	113	95	15.9
Aircraft	42	114.5	98	14.4
	48	124.5	108.5	12.9

TABLE XVII

EFFECTS OF VARYING THE NUMBER
OF FUEL TRUCKS
AT VARIOUS AIRCRAFT LEVELS
WITH 16 MAINTENANCE TEAMS

		Maintenance Generated Aircraft # of Fuel Trucks		
		2	3	4
	24	68.5	66	66
Number	30	78	74	74
of	36	91.5	92	92
Aircraft	42	93.5	96.5	96.5
	48	96	98	98

Summary

The model output was constructed with bookkeeping in mind. The capability to vary both the levels of aircraft and maintenance teams, as well as the individual variables, gives the result of changes in a tabular manner, aiding analysis. The method of analysis used is that of a nonparametric test, the Friedman Test. This test was used to measure the effects of changing the levels of maintenance manning at differing levels of aircraft available. The roles of these two variables were then reversed to ensure that the level of manning were causing the changes in aircraft generations and, hence, the turn rate, not merely the level of aircraft. Parametric analysis of the data was not possible due to the failure of meeting the assumptions required for their use. These tests were run to measure the effects caused by changes in the levels used, as they applied to the resultant turn rate.

The turn rate is the measure of effectiveness used in this thesis. The results of running the model at various levels was to tabularize the turn rates achieved at these levels, and then select a level of maintenance to best meet the desired turn rate for a given level of aircraft. For the example used, of 24 aircraft and a desired turn rate of 3.22, an increase of 25 percent in manning is required, from the present eight teams to ten.

The results of the analysis on the levels of maintenance indicate a significant difference between adjoining maintenance team levels at this range, so the increase of two teams over the present eight available is recommended.

The number of sorties flown was also of interest, as it is a measure of the capability of the air base to fight the war. The results of these tests are similar to that for aircraft generation, and therefore do not change the previous results.

Sensitivity analysis was performed on four different variables to measure their impact on the model results. Of the four variables analized, only the percentage of little damaged aircraft was significant. This indicated that small changes in the percentage of aircraft destroyed and damaged in flight could vary the percentage of aircraft generated by approximately 10 percent at the ratio of aircraft to maintenance recommended for the desired turn rate. The remaining three variables analized were the abort rate, maintenance delays on aborted aircraft, and the number of fuel trucks available. At the recommended level of maintenance to aircraft they did not drastically effect the results, less than five percent.

As previously mentioned, the results of this analysis is for comparison of the effects of varying the different levels of maintenance to aircraft. Precise re-

commendations are not possible due to the uncertainty of the input parameters. The first method of validating the output of this model was by making comparisons against the results of the Quest model. Similar input parameters were used for both models, Quest and the one presented here, and the results of the two models on turn rate achieved are comparable. Reasons for the differing results are based on the degree of realism modeled, their model does not take into account aborts and battle damaged aircraft or formation take-offs. Both reports indicate a need to increase the level of maintenance required to reach the turn rate used as an example, of 3.22.

In the next chapter, the results of this analysis, as it applies to the goals specified in Chapter I of model development and required maintenance manning, will be presented. Recommended changes to the model, based on the loosening of some of the assumptions used in its development will also be presented.

The second way of validation is by an intuitive process. It is reasonable to assume that an increase in the time to perform maintenance tasks will result in a lower turn rate, for a specified level of maintenance and aircraft. Therefore, an increase in maintenance manning is required to reach a required turn rate.

IV: Conclusions and Recommendations

Summary

The maintenance manning requirements for an air base of fighter aircraft in a chemical environment was the topic of this thesis. The reasons behind this study were covered as the current threat, and the contention that the present manning might not be sufficient. Data is not currently in existance for the maintenance operations of an F-4 squadron in a chemical environment. For this reason data was used from operations in a conventional war scenario and modified to account for chemical war. A simulation model was constructed to measure the capabilities of maintenance to support the air operations. Data was then collected and analized to determine if the current level of maintenance, or some higher level, is needed to reach a turn rate consistant with current policy. The two objectives, or goals, of this thesis have been realized.

Conclusions

Three areas will be covered in this section. The first will be on the simulation model. The second area is on the significant factors presented in the sensitivity analysis section of the last chapter. The final area cov-

ers the manning requirements of maintenance. The first and last of these are to meet the objectives of this thesis and the middle one to explain the effects of changing parameters.

Model Viability. A simulation model, that is highly flexible, is the only viable method to make comparisons within the chemical warfare scenario. It cannot give exact answers to the effects on operations in this threat, but it does make estimates. By changing the inputs, comparisons can be made, and the effects of the changes can be seen quickly. The flexibility designed into the model allows changes to be made easily and allows for additions of further capabilities.

Significant Factors. The effects of changing the air abort rate, maintenance delays on aborted aircraft, and the number of fuel trucks available, do not significantly change the number of aircraft generated at the level of maintenance to aircraft recommended for use. The results of changing the percentage of aircraft destroyed and damaged from .06 and .09, to .10 and .20, respectively, did have a significant effect on the number of aircraft that could be generated, approximately 10 percent. The primary factor that led to the results of this model is the burden imposed by wearing the chemical defense ensemble. As mentioned at the introduction of sensitivity

analysis, further analysis on these parameters was not performed, beyond their development for the model.

Maintenance Manning. The current level of maintenance manning, of one team to three aircraft, is not sufficient to meet the desires of a theater commander, as presented in the Quest document. As presented in the previous chapter, a ratio of one team per 2.5 aircraft is more realistic. This corresponds to an increase of nearly 25 percent. The model given in this thesis does not take into account the effects of incapacitation and death that would be encountered in a chemical attack. Therefore, the turn rates given in the analysis need to be lowered if personnel are removed from operations. An increase in manning of 25 percent would not be unreasonable and may, in fact, be low when personnel are removed from the system.

Recommendations

The model presented is but a first cut at the operations of maintenance, let alone an air base, in a chemical environment. Several areas need to be researched and included in this model, or in one similar to it, to remove the restrictive assumptions made in Chapter II.

Personnel Incapacitation. In this model, advanced warning and the availability of equipment is assumed, so all personnel remain operational. There are presently several studies and models being utilized by the Chemical Warfare Division of the Aerospace Medical Research Laboratory (AMRL) that deal with incapacitation of personnel. These models need to be analized for their capabilities to make predictions on incapacitation, and the results incorporated in this model.

Equipment Improvements. The equipment that is utilized in the chemical defense ensembles are continuously being improved. These improvements will reduce both the heat build-up factors and the time to perform tasks. Research into the future status of the ensembles and the effects the improvements bring about must be continued. Appendix E gives a listing of the current ensembles.

Improvements are also being made in the aircraft systems that may reduce the air abort rate. The abort rate in this model includes physiological effects on the aircrew.

Appendix B gives a brief discription of the environmental control systems that are under development for most aircraft types. This would reduce the number of aircraft that abort. It could also have an effect on the percentages of aircraft that are destroyed and damaged. The capabilities of the aircrew is somewhat limited by the current ensemble.

As the equipment is improved, the overall capabilities of the personnel, both ground and aircrew, will be improved. Not only must the amount of research into new equipment be increased, the ability of a modeler to incorporate these changes on an unclassified level in a model, must be expanded.

Resource Availability. The amount of resources at the field are considered limitless. This includes the amount of fuel and munitions, and the amount of chemically protective equipment. The actual amounts of these commodities at particular fields need to be incorporated into the model. This could be done, based on the time it takes for the particular events, fuel and loading of guns and missiles, to occur. A second method could be based on the flight time of the aircraft. The longer the flight, the more fuel used and the more likely that armaments were expended. In both cases, time could be used to model the amount of resources used by each aircraft. Then

as they are used, a bookkeeping system could be used to ensure that the levels of supply are not exceeded.

Comments

The main benefit of a simulation model is the learning process it forces on the modeler. The methodology used on the design of this model was systematic, from literature search through problem definition, to the simulation model. As assumptions are loosened, or more detail is required, the size of the model must increase. The material presented in this thesis incorporates research into many areas and should provide a good reference on the problems of operations in a chemical environment.

Bibliography

1. Bills, Ray W., Major, US Army. "Position on Chemical Disarmament?" Military Review, 55: 12-23 (May 1975).

2. Brosnan, John F. Jr., Major, USMC. "A Case for Marine Corps Chemical Warfare Readiness", United States Naval Institute Proceeding, 105: 108-111 (November 1979).

3. Chapman, Betty. "Chemical Warfare: The Dirty Weapon", National Defense. 33-37 (June 1980).

4. Conover, W. J. Practical Nonparametric Statistics. Second Edition. John Wiley and Sons, New York 1980.

5. Currie, Malcolm R. "DoD Policy: Chemical Warfare and Biological Research", Commanders Digest, 18: All (3 July, 1975).

6. Erickson, John. "The Soviet Union's Growing Arsenal of Chemical Warfare", Strategic Review, 7: 63-71 (Fall 1979).

7. Fallon, Paul F., Lt Col, USAF, and Major Charles M. Leone. USAF. "US Aircrew Chemical Defense Assemlies", AGARD CP 264 Suppl. 21-1 -21-5 (22-26 January 1979).

8. Fullerton, John. "The Chemical Equation", Defense & Foreign Affairs Digest, 12: 42-43 (December 1978).

9. Harvey, David. "Fighting the Chemical Fight", Defense & Foreign Affairs, 7: 18-20 (July 1980).

10. Kyle, Deborah M. "Invisable; Not Invincible: Weakening the Threat of Chemical Warfare", Armed Forces Journal International, 117: 46-48 (July 1980).

11. McCambridge, John J., Col, USAF, and Major Charles M. Leone, USAF. "Integration of Protection Against Chemical Warfare Agents with Aircrew Personal Equipment", AGARD CP 264 Suppl. 32-1 - 32-3 (22-26 January 1979).

12. Parker, David M., Lt Col US Army. "Facing the NBC Environment", Military Review, 54: 24-35 (May 1974).

13. Pilmer, Richard, Col, USAF, and MSgt Christopher R. Yancey. "CD Man Revisited", TAC ATTACK, 20: 4-7 (May 1974).

14. Pritsker, A. Alan B. Modeling and Analysis Using Q-GERT Networks. John Wiley and Sons, New York, 1979.

15. Rothschild, J. H. Tomorrow's Weapons: Chemical and Biological. New York: McGraw-Hill Book Company, 1964.

16. Shannon, Robert E. Systems Simulation, The Art and Science. Prentiss-Hall, Inc., Englewood Cliffs, 1975.

17. Smith, L. E., USAF. Chemical Defense Program 64601F. February 1981.

18. Walsh, Thomas L. "The Modern Barbarians", Armed Forces Journal International, 117: 50+ (July 1980).

19. Walpole, Ronald E., and Raymond H. Myers. Probability and Statistics for Engineers and Scientists. Second Edition. MacMillan Publishing Co., Inc., New York, 1978.

20. Weger, Nikolas P. "Therapy on Nerve Agent Poisoning", AGARD CP 264 Suppl. 10-3 (22-26 January 1979).

21. AFMSMET; "F-4E Aircraft Maintenance Support General Job Standards". 20 September 1979.

22. Control Analysis Corporation. "TAC Turner Final Report". June 1978.

23. MAC 01-81. Mission Elements Need Analysis (MENA). Scott AFB: HQMAC/XPQSC, 13 February 1981.

24. NA-800-115-4. Environmental Control System Study, Phase 4. Los Angeles: Rockwell International, 17 April 1981.

25. Quest Research Corporation. "A Limited Assessment of Ground Operations in a Chemical Warfare Environment at a typical USAFE Base". Section 10 only (Draft), 25 February 1981.

26. TAF 328-75. Point Chemical Warning Agent Detection and Alarm System. Langley AFB, 1975.

27. U.S. Army Armament Research and Development Command. "Mathematical Modeling of Personnel Degradation PDGRAM". 29 May 1979.

APPENDIX A

This appendix contains two tables, Table XVIII is a partial list of chemical agents that would be used as weapons (Ref. 15:196-197). Table XIX shows the survival rates and times of experimental animals exposed to Soman and Sarin, both nerve agents, after being given antidotes (Ref. 20:10-3).

As shown in Table XIX, if a person is exposed to a nerve agent when unprotected, the probability of survival is less than assured. Those that do survive would be incapacitated and not able to perform their designated tasks.

TABLE XVIII

CHEMICALS USED AS WEAPONS

Name of Agent U.S. Symbol	*Physical State at 68° F.*	*Dissemi-nated Form*	*Odor*	*Median Lethal Dosage on Inhalation * mg.-min./m.³*	*Median Incapacitating Dosage on Inhalation mg.-min./m.³*	*Eye and skin ** Toxicity*
Phosgene CG	Colorless gas.	Gas.	New-mown hay; green corn.	3,200	1,600	None.
Tabun GA	Colorless to brown liquid.	Aerosol, liquid or gas.	Faintly fruity. None when pure.	400 (resting men) 100 (active men)	300 (resting men)	Eyes: Very high. Skin: 1½ grams liquid (30 drops).
Sarin GB	Colorless liquid.	Gas or liquid.	Almost none when pure.	70 (mild activity) 25 (active men)	35 (mild activity)	Eyes: Very high. Skin: 15,000 * lethal for gas. 2 grams liquid (40 drops) thru ordinary clothing. 8,000 ** incapacitating for gas.
VX	Colorless liquid. (persistent)	Aerosol or liquid.	None.			Eyes: Very high. Skin: Very high.
Mustard HD	Colorless to pale yellow liquid.	Gas or liquid.	Garlic. Very little if pure.	1,500 (resting men) 400 (active men)		Eyes: 200 ** incapacitating. Skin: 2,000 ** incapacitating for gas.
CS	White crystalline solid.	Aerosol.	Pungent, peppery.			Lethality low but incapacitating at 1-5 mg./m.³

* Concentration times exposure (milligrams per cubic meter times minutes) to cause death in 50% of subjects. The numbers are directly comparable to indicate lethality of the agents.

** Same as above but to cause incapacitation in 50% of subjects.

TABLE XVIII (CONT)

Time of Onset of Symptoms	*Physiological Action*	*Protection Required*	*Decontamination*	*Tactical Use*	*First Aid*
Immediate to 24 hours.	Damages the lungs.	Mask.	None in open. Aeration in closed spaces.	Lethal agent, delayed or immediate action.	If shortness of breath occurs, rest and keep warm.
Inhalation: Very rapid. Skin: ½–1 hour.	Anticholinesterase agent (nerve gas).	Mask and protective clothing.	Bleach slurry. Dilute alkaline solution. Hot soapy water. DS2.	Lethal agent. Inhalation or spray.	Atropine. Artificial respiration.
Inhalation: Very rapid. Skin: ½–1 hour.	Anticholinesterase agent (nerve gas).	Mask and protective clothing.	Same as for Tabun.	Lethal agent. Inhalation or spray.	Atropine. Artificial respiration.
Inhalation: Very rapid. Skin: ½–1 hour.	Anticholinesterase agent (nerve gas).	Mask and protective clothing.	Same as for Tabun.	Lethal agent. Inhalation or spray.	Atropine. Artificial respiration.
Delayed. 4–6 hours.	Injures eyes and lungs. Blisters skin.	Mask and protective clothing. Protective ointment.	Bleach DS2.	Incapacitating agent. Inhalation, skin effects from gas, spray.	Protective ointment on exposed skin (within 5 minutes). If liquid present, blot off first.
Instantaneous.	Extreme burning and tearing of eyes. Difficult breathing. Stinging of skin. Nausea.	Mask.	None	Incapacitating agent on inhalation. Normally a riot agent, but may be used as a war agent.	Face wind in fresh air. Do not rub eyes.

TABLE XIX

SURVIVAL RATE AND SURVIVAL TIME AFTER POISONING

WITH
5 LD_{50} OF SOMAN

Antidotes	uMol/kg	number of animals	survived	survival rate %	survival time (min)
HGG 12-Cl HGG 42 J	3 3	8	3	37	3840
HGG 12-Cl	15	6	0	0	183
HGG 12-Cl	40	6	4	66	1490
HGG 42-J	15	5	1	20	450
HGG 42-J	30	6	5	83	17280
HGG 42-Cl	30	6	0	0	1788
HGG 42-J OBIDOXIN	15 50	6	1	17	471
HGG 42-J OBIDOXIN	30 50	6	3	50	2880

WITH
5 LD_{50} CF SARIN

Antidotes	uMol/kg	number of animals	survived	survival rate %	survival time (min)
HGG 12-Cl	3	4	2	50	48
HGG 42-J HGG 12-Cl	3 30	6	1	17	13
HGG 42-J	30	6	3	50	33
		10 LD_{50} VX			
HGG 12-Cl HGG 42-J	3 3	6	4	66	3333
		15 LD_{50} VX			
HGG 12-Cl	30	6	2	33	120
HGG 42-J	30	6	4	66	-

APPENDIX B

The aircrew members are currently required to wear the chemical defense ensemble for all flights in a chemical environment. The effects of wearing the ensemble are taken account of in the rates of air aborted, destroyed, and damaged aircraft. Research is currently underway to reduce the amount of agents that can enter the aircraft, and remove the agents that do enter. With a reduced threat, the wearing of the full ensemble might not be required. This would reduce the physiological effects on the crew members and remove some limitations of dexterity and vision. The effects would be a reduced percentage of aircraft that air abort or are damaged and destroyed.

Pertinent Data on the Environmental Control System

The concentration of contaminates in the cockpit/cargo compartment is dependent on the air supply inlet concentration of chemical agents and the exchange rate of air in the cockpit/cargo compartment.

These variables are related by the following equation.

$$\frac{C_{in} - C_{dO}}{C_{in} - C_{initial}} = e^{-\left(\frac{wdO}{pV}\right)}$$

where	C_{in}	concentration of the incoming air
	C_{dO}	concentration in the cabin at the end of the time interval
	$C_{initial}$	concentration in the cabin at the start of the time interval
	w	inflow rate of cabin air
	dO	time interval
	p	density of the air entering the cabin
	V	cabin volume
	$\frac{w}{pV}$	rate of air changes

The top charts of Figures 11 and 12 are computer verification runs (CVR) and the bottom charts are for an F-4 aircraft. The measurement of concentration is expressed as parts per million (PPM) or milligrams per cubic meter.

Table XX gives data on the different aircraft if they were to use the Environmental Control System (Ref. 24: Appendix 6).

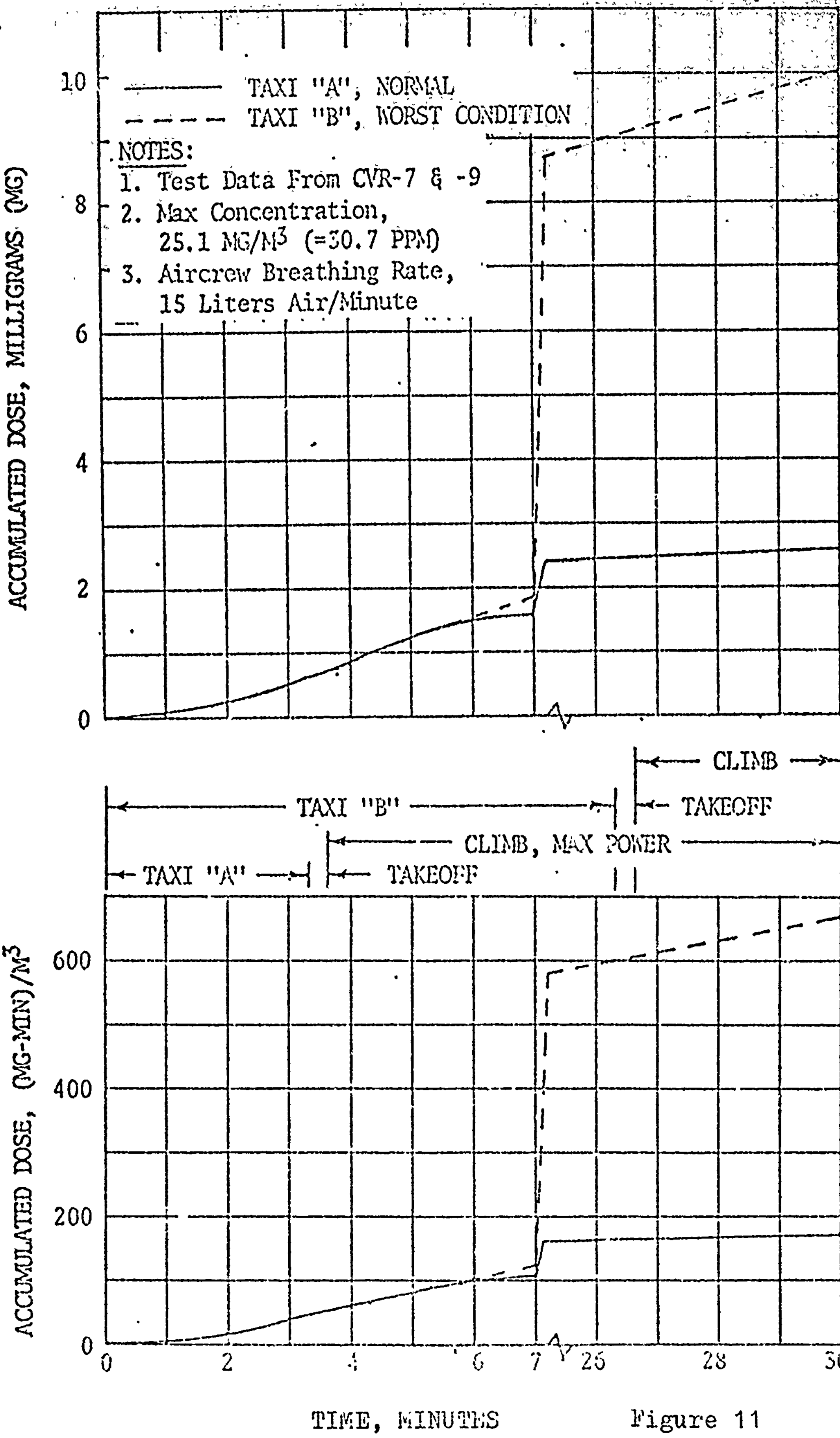
TAXI "A", NORMAL
TAXI "B", WORST CONDITION
NOTES:
1. Test Data From CVR-7 & -9
2. Max Concentration,
25.1 MG/M3 (=30.7 PPM)
3. Aircrew Breathing Rate,
15 Liters Air/Minute
ACCUMULATED DOSE, MILLIGRAMS (MG)
0
2
4
6
8
10
CLIMB
TAXI "B"
TAKEOFF
CLIMB, MAX POWER
TAXI "A"
TAKEOFF
ACCUMULATED DOSE, (MG-MIN)/M3
0
200
400
600
0
2
4
6
7
25
28
30
TIME, MINUTES

Figure 11

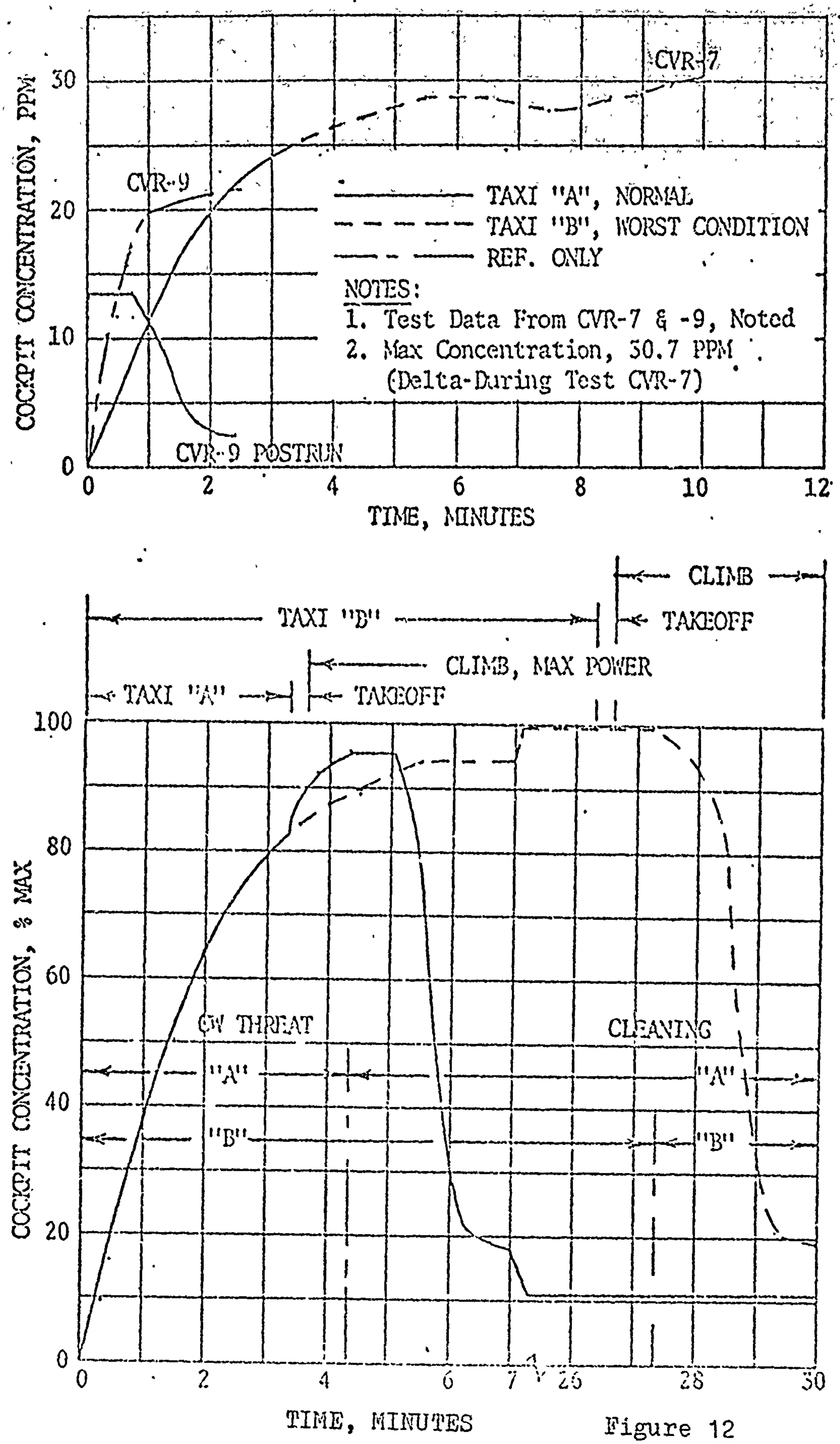
CVR-7
CVR-9
CVR-9 POSTRUN
TAXI "A", NORMAL
TAXI "B", WORST CONDITION
REF. ONLY
NOTES:
1. Test Data From CVR-7 & -9, Noted
2. Max Concentration, 30.7 PPM
(Delta-During Test CVR-7)
COCKPIT CONCENTRATION, PPM
TIME, MINUTES
TAXI "B"
CLIMB
TAKEOFF
CLIMB, MAX POWER
TAXI "A"
TAKEOFF
CW THREAT
"A"
"B"
CLEANING
"A"
"B"
COCKPIT CONCENTRATION, % MAX
TIME, MINUTES

Figure 12

AIRCRAFT ECS CHARACTERISTICS - SEA LEVEL STATIC, STANDARD ATMOSPHERE

AIRCRAFT	VOLUME FT^3	CREW STATION						ENGINE BLEED AIR					
		AIR CHANGES PER MINUTE		AIRFLOW LB/MIN		FLOW RATE LB/MIN		PRESSURE PSIA		TEMP °F		DWELL TIME COMP. BLEED TO ECS INLET SEC.	
		MAX	IDLE	MAX	IDLE	MAX	IDLE	MAX	IDLE	MAX	IDLE	MAX	IDLE
A-7	60	5.2	2.0	24	9.0	30	9	265	42	830	300	.16	1.25
A-10	60	5.5		25				137		738			
F-4E	150	2.58	.85	30	9.5	118	30	155	34	750	305	.58	.5
F-5E	50	8.1	.9	31	4.6	35	7	133	22	564	160	.12	.22
F-15	75	7.4		43				261		970			
F-16	60	4.4		20				260		970			
F-111F	90	8.7	1.75	60	12.0	200	150	164	43	830	300	.18	.2
B-1*	600	.52	.56	25	26.0	432	384	139	57	760	512		
B-52D	1830	1.1		170				255		756			
B-52H	1830	1.5	.25	212	32.0	300	32	220	28	756	260	.86	.07
C130E	750	.55	.55	32	31.0	108.6	102	130	52	600	310	2.1	1.0
C-141	1250	.96		100				82		450			
KC-135	1300	1.2		118				255		756			

*Hot Atmosphere

TABLE XX

APPENDIX C

PROGRAM LISTING

```
 XT4,CH25Ø02Ø,T7Ø,IO7Ø.T8ØØ854,TAFT,BOX4579
FTN5,ANSI=Ø,LO=Ø.
ATTACH,PROCFIL,QGERTPROC,ID=AFIT.
BEGIN,QGERT,,M=LGO,MODE=X.
      SUBROUTINE UI
C**
C**
C**             VARIABLE LIST
C**
C**   A1      TIME TO PERFORM AERO 7 INSPECTION
C**   A2      TIME TO PERFORM RELOADING OF GUNS
C**   A3      TIME TO PERFORM EXTERNAL FUEL TANK PLACEMENT OR REMOVAL
C**   A4      TIME TO PERFORM MISSILE UPLOAD
C**   A5      TIME TO PERFORM PREFLIGHT
C**   A6      TIME TO PERFORM REFUELING
C**   A7      HEAT BUILDUP ENCOUNTERED DURING AERO7 AND RELOADIND
C**   A8      HEAT BUILDUP ENCOUNTERED DURING CHANGEOVER OF EXTERNAL TANK
C**   A9      HEAT BUILDUP ENCOUNTERED DURING MISSILE UPLOAD
C**   A10     HEAT BUILDUP ENCOUNTERED DURING REFUELING
C**   A11     HEAT BUILDUP ENCOUNTERED DURING REFUELING
C**   A12     SIMULATION TIME THAT PREFLIGHT IS COMPLETE
C**   A13     SIMULATION TIME THAT AIRCRAFT IS AVAILABLE FOR REFUELING
C**   A14     TIME SPENT AWAITING REFUELING BY AIRCRAFT
C**   A15     CURRENT HEAT BUILDUP INSIDE SUITS OF MAINT TEAM
C**   A16     CURRENT HEAT BUILDUP INSIDE SUITS OF ARMING TEAMS
C**
C**
C**             ATTRIBUTE LIST
C**
C**   1      WING TANK STATUS
C**   2      FUEL STATUS
C**   3      AIRCRAFT NUMBER
C**   4      MX TEAM NUMBER
C**   5      AIRCRAFT OR FUEL TRUCK
C**   6      HEAT BUILDUP OF MAINT TEAM
C**   7      HEAT BUILDUP OF ARMING TEAM
C**
C**
```

```
      COMMON/QVAR/NDE,NFTBU(500),NREL(500),NRELP(500),NRELZ(500),
     +NRUN,NRUNS,NTC(500),PARAM(100,4),TBEG,TNOW
      COMMON/RET/A1(50),A2(50),A3(50),A4(50),A5(50),A6(50),
     +A7(50),A8(50),A9(50),
     +A10(50),A11(50),A12(50),A13(50),A14(50),A15(50),A16(50),
     +W(16),IC(16)
      COMMON/VAR/I,J,K,L,N,X,AIRAB,DEST,DAMG,FLTS
      REAL  LO
      INTEGER  PLUS,SUM,X,K1,K2,K3,K4,K5,K6,NUMB,
     +AIRAB,DEST,DAMG,FLTS
      DATA  A1,A2,A3,A4,A5,A6,A7/350*0.0/
      DATA  A8,A9,A10,A11,A12,A13,A14/350*0.0/
      DATA A15,A16/100*0.0/
      DATA  W/16*0.0/
      DATA  AIRAB,DEST,DAMG,FLTS/4*0/
      DATA IC/16*0/
      DATA  I,J,K,L,X/5*0/
      CALL CPLO(8)
      CALL CPLO(9)
      CALL CPLO(10)
      CALL CPLO(11)
      CALL CPLO(12)
      CALL CPLO(13)
      RETURN
      END
C**
C**
C**
C**
C**
C**
      SUBROUTINE US (ISN,DTIM)
      COMMON/QVAR/NDE,NFTBU(500),NREL(500),NRELP(500),NRELZ(500),
     +NRUN,NRUNS,NTC(500),PARAM(100,4),TBEG,TNOW
      COMMON/RET/A1(50),A2(50),A3(50),A4(50),A5(50),A6(50),
     +A7(50),A8(50),A9(50),
     +A10(50),A11(50),A12(50),A13(50),A14(50),A15(50),A16(50),
     +W(16),IC(16)
      COMMON/VAR/I,J,K,L,N,X,AIRAB,DEST,DAMG,FLTS
      DIMENSION RATT(8),BATT(8)
      REAL  LO
      INTEGER  PLUS,SUM,X,K1,K2,K3,K4,K5,K6,NUMB,
     +AIRAB,DEST,DAMG,FLTS
      GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16), ISN
```

```
C**   AFTER AIRCRAFT HAVE FINISHED PREFLIGHT A FLT OF TWO
C**   TAKEOFF.  UPON TAKEOFF THEY RE-ENTER THE SYSTEM AT
C**   NODE 45.
C**
 1      X=X+1
        RT=GATRB(3)
        CALL PATRB(RT,3)
        PRINT*,'TIME IS ',TNOW,' ACRF ',RT
        DTIM=10000.0
        IF(X.LT.1.5) THEN
C**     LEAD AIRCRAFT
        CALL GETAT(BATT)
        TKOFF1=0.0
        CALL STSER(45)
        RETURN
        ENDIF
        CALL GETAT(RATT)
C**     SECOND AIRCRAFT
        TKOFF2=0.001
        FLTS=FLTS+1
C**     PLACES FORMATION IN NODE 45
        CALL PTIN(45,TKOFF1,TNOW,RATT)
        CALL PTIN(45,TKOFF2,TNOW,BATT)
        CALL STSER(45)
        X=0
        RETURN
C**
C**     SET PARAMETERS ON AIRCRAFT
C**     THESE PARAMETERS MAY BE CHANGED IN THE
C**     QGERT MODEL.  UP TO 50 AIRCRAFT MAY BE USED,
C**     TO ALLOW FOR MORE AIRCRAFT RESET ARRAY SIZES
C**     IN COMMON RET.  NUMBER OF AIRCRAFT MUST ALSO
C**     BE SET IN ACTIVITY 1.
C**
 2      I=IFIX(GATRB(3)+0.1)
        J=IFIX(GATRB(4)+0.1)
        A1(I)=LO(8)
        A2(I)=LO(9)
        A3(I)=LO(10)
        A4(I)=LO(11)
        A5(I)=LO(12)
        A6(I)=LO(13)
        A7(I)=1.47*A1(I)+1.97*A2(I)
        A8(I)=1.47*A3(I)
        A9(I)=2.47*A4(I)
        A10(I)=0.83*A6(I)
        A11(I)=0.47*A5(I)
        DTIM=0.0
        PRINT*,'AIRCRAFT ',I,' PLACED IN NODE 5 AT ',TNOW
        RETURN
```

```
C**   PLACES AIRCRAFT INTO THE SUBNETWORK
C**   UP TO 16 MX TEAMS ARE ALLOWED.  TO LIMIT
C**   THE NUMBER OF MX TEAMS USED, THE NUMBER OF
C**   TEAMS MUST BE SET IN QGERT MODEL ACTIVITY 51.
C**   THE LAST NUMBER MUST EQUAL THE NUMBER OF MX
C**   TEAMS MINUS 1, THIS ELIMINATES TRANSACTION PASSAGE
C**   UNLESS AT LEAST ONE MX TEAM IS AVAILABLE.
C**   THE STATEMENT L=50 IS PLACED IN THE IF STATEMENT
C**   FOR THE LAST MX TEAM TO BE USED.
C     THE VALUE OF N MUST ALSO BE SET IN US3.
C**
 3    CALL GETAT(RATT)
      DTIM=0.0
      K=IFIX(GATRB(3)+0.1)
      NUMB=0
      ICOUNT=1.0E20
      N=16
      DO 50 I=1,N
      IF(ICSRA(I).GT.0.5) THEN
      IF(ICOUNT.LT.IC(I)) THEN
      ICOUNT=IC(I)
      NUMB=I
      ENDIF
      ENDIF
 50   CONTINUE
      GO TO (101,102,103,104,105,106,107,108,109,110,
     +111,112,113,114,115,116),NUMB
C**   ASSIGNS MX TEAM 1
C**   CHECK STATUS OF MX TEAM 1, IF AVAILABLE
C**   ASSIGN AIRCRAFT TO APPROPRIATE SUBNETWORK.
C**   IF NOT, CHECK STATUS OF NEXT MX TEAM.
C**   THESE LINES ARE THE SAME FOR ALL
C**   TEAM "IF" LOOPS
 101  PLUS=NODCV(90,1)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I = 1
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 2
 102  PLUS=NODCV(90,2)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I = 2
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 3
 103  PLUS=NODCV(90,3)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I = 3
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
```

```
C**   ASSIGNS MX TEAM 4
 104  PLUS=NODCV(90,4)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I = 4
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 5
 105  PLUS=NODCV(90,5)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I = 5
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 6
 106  PLUS=NODCV(90,6)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I = 6
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 7
 107  PLUS=NODCV(90,7)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I = 7
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 8
 108  PLUS=NODCV(90,8)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I = 8
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 9
 109  PLUS=NODCV(90,9)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I=9
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 10
 110  PLUS=NODCV(90,10)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I=10
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 11
 111  PLUS=NODCV(90,11)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I=11
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
```

```
C**   ASSIGNS MX TEAM 12
 112  PLUS=NODCV(90,12)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I=12
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 13
 113  PLUS=NODCV(90,13)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I=13
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 14
 114  PLUS=NODCV(90,14)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I=14
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 15
 115  PLUS=NODCV(90,15)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I=15
      IC(I)=IFIX(IC(I)+1.1)
      GO TO 600
C**   ASSIGNS MX TEAM 16
 116  PLUS=NODCV(90,16)
      CALL PTIN(PLUS,0.0,TNOW,RATT)
      I=16
      IC(I)=IFIX(IC(I)+1.1)
      L=50
      GO TO 600
C**   IF ALL MX TEAMS HAVE BEEN ASSIGNED AT LEAST ONCE,
C**   THE HEAT BUILD UP OF THE TEAM IS PLACED ON THE
C**   TEAMS THAT HAVE ALREADY BEEN ASSIGNED AT LEAST ONCE>
 600  IF(L.GT.25) THEN
      RT=A15(I)-0.03*(TNOW-A12(I))
      IF(RT.LT.30.0) THEN
      RT=30.0
      ENDIF
      E=A16(I)-0.03*(TNOW-A12(I))
      IF(E.LT.30.0) THEN
      E=30.0
      ENDIF
      CALL PATRB(RT,6)
      CALL PATRB(E,7)
      ENDIF
      PRINT*,'MAINT TEAM ',I,' WORKED ',W(I),' TO THIS POINT.'
      PRINT*,'AIRCRAFT ',K,' PLACED IN NODE 90/',I,' AT ',TNOW
      RETURN
```

```
C**   RELOAD GUNS AND AERO 7 INSPECTION IF AIRCRAFT HAS WING TANKS
C**
C**   THERMAL STRESS VALUES ON MX TEAMS ARE
C**   RESET AND TIMES ADJUSTED FOR REQUIRED
C**   DELAYS, IF APPLICABLE.  PLACES AIRCRAFT
C**   INTO NEXT PHASE OF MAINTAINENCE REQUIRED
C**   AT APPROPRIATE TIME.  THIS IS THE SAME
C**   FROM US 4 THROUGH US 11.
C**
C**   GET AIRCRAFT NUMBER
 4    I = IFIX(GATRB(3) + 0.1)
C**   GET MX TEAM WORKING ON AIRCRAFT
      J=IFIX(GATRB(4)+0.1)
      PRINT*,'TIME IS ',TNOW,' AIRCRAFT ',I,' HAS WING TANKS'
      DTIM = 600.0
C**   INCREASE HEAT BUILDUP ON MX TEAM
      RT=GATRB(6)+A7(I)
      E=GATRB(7)+A7(I)
C**   INCREMENT WORK TIME OF MX TEAM
      W(J)=W(J)+A2(I)
C**   GET NODE NUMBER IN SUBNETWORK
      SUM = NODCY(19,J)
C**   IF HEAT BUILDUP EXCEEDS 70 ON EITHER MAINT OR
C**   ARM.NG TEAM, PLACE TEAM IN REST
      IF(RT.GT.70.0.OR.E.GT.70.0) THEN
C**   DECREASE HEAT BUILDUP
      TM=RT-40.0
      V=E-40.0
C**   CALCULATE TIME TO COMPLETE TASK INCLUDING REST PERIOD
      S=A2(I)+48.19
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT
      CALL PATRB(TM,6)
      CALL PATRB(V,7)
      CALL GETAT(RATT)
C**   PLACE TRANSACTION INTO SYSTEM AT NEXT NODE
      CALL PTIN(SUM,S,TNOW,RATT)
      RETURN
      ENDIF
C**   IF A REST IS NOT REQUIRED
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT
      CALL PATRB(RT,6)
      CALL PATRB(E,7)
      CALL GETAT(RATT)
C**   PLACE TRANSACT.ON INTO SYSTEM AT NEXT NODE
      CALL PTIN(SUM,A2(I),TNOW,RATT)
      RETURN
C**
```

```
C**   RELOAD GUNS AND AERO 7 INSPECTION IF AIRCRAFT DOES NOT
C**   HAVE WING TANKS.(CHECK COMMENTS IN US 4)
C**
 5    I = IFIX(GATRB(3) + 0.1)
      J=IFIX(GATRB(4)+0.1)
      PRINT*,'TIME IS ',TNOW,' AIRCRAFT ',I,' HAS NO WING TANKS'
      DTIM = 600.0
      RT=GATRB(6)+A7(I)
      E=GATRB(7)+A7(I)
      W(J)=W(J)+A2(I)
      SUM = NODCV(21,J)
      IF(RT.GT.70.0.OR.E.GT.70.0) THEN
      TM=RT-40.0
      V=E-40.0
      S=A2(I)+40.19
      CALL PATRB(TM,6)
      CALL PATRB(V,7)
      CALL GETAT(RATT)
      CALL PTIN(SUM,S,TNOW,RATT)
      RETURN
      ENDIF
      CALL PATRB(RT,6)
      CALL PATRB(E,7)
      CALL GETAT(RATT)
      CALL PTIN(SUM,A2(I),TNOW,RATT)
      RETURN
```

```
C**   PUT TANKS ON AIRCRAFT
C**   IF AIRCRAFT DOES NOT HAVE WING TANKS,
C**   IT PLACES THEM ON THE AIRCRAFT WITH A PROBABILITY
C**   OF .5.  THIS IS TO SIMULATE SCHEDULING
C**   OF AIRCRAFT FOR A MISSION THAT REQUIRES
C**   WING TANKS
C**
C**   GET AIRCRAFT NUMBER
 6    I = IFIX(GATRB(3) + 0.1)
C**   GET MX TEAM NUMBER WORKING ON AIRCRAFT
      J=IFIX(GATRB(4)+0.1)
      PRINT*,'TIME IS ',TNOW,' AIRCRAFT ',I,' TANKS PUT ON'
      DTIM = 600.0
C**   INCREASE HEAT BUILDUP ON MX TEAM
      RT=GATRB(6)+A8(I)
      E=GATRB(7)-A8(I)
C**   INCREMENT WORK TIME ON MX TEAM
      W(J)=W(J)+A3(I)
C**   CHECK NODE NUMBER IN SUBNETWORK
      SUM = NODCV(24,J)
      IF(RT.GT.70.0) THEN
C**   IF HEAT BUILDUP EXCEEDS 70,
C**   INCREASE TIME TO COMPLETE TASK BY REST PERIOD
      S=A3(I)+48.19
C**   REDUCE HEAT BUILDUP ON MX TEAM
      TM = RT - 40.0
      V=E-40
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT
      CALL PATRB(TM,6)
      CALL PATRB(V,7)
      CALL GETAT(RATT)
C**   PLACE TRANSACTION INTO SYSTEM AT NEXT NODE
      CALL PTIN(SUM,S,TNOW,RATT)
      RETURN
      ENDIF
C**   IF NO REST PERIOD IS REQUIRED
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT
      CALL PATRB(RT,6)
      CALL PATRB(E,7)
      CALL GETAT(RATT)
C**   PLACE TRANSACTION INTO SYSTEM AT NEXT NODE
      CALL PTIN(SUM,A3(I),TNOW,RATT)
      RETURN
```

```
C**   TAKE TANKS OFF AIRCRAFT
C**   IF AIRCRAFT HAVE WING TANKS ON, IT
C**   REMOVES THE TANKS WITH A PROBABILITY
C**   OF .5, TO SIMULATE SCHEDULING OF AIRCRAFT
C**   THAT REQUIRE NO EXTERNAL FUEL TANKS.
C**
C**   GET AIRCRAFT NUMBER
      I = IFIX(GATRB(3) + 0.1)
C**   GET MX TEAM NUMBER WORKING ON AIRCRAFT
      J=IFIX(GATRB(4)+0.1)
      PRINT*,'TIME IS ',TNOW,' AIRCRAFT ',I,' TANKS COMING OFF'
      DTIM = 600.0
C**   INCREASE HEAT BUILDUP ON MX TEAM
      RT=GATRB(6)+E8(I)
      E = GATRB(7) - A8(I)
C**   INCREMENT WORK TIME ON MX TEAM
      W(J)=W(J)+A3(I)
C**   CHECK NODE NUMBER IN SUBNETWORK
      SUM = NODCV(25,J)
      IF(RT.GT.70.0) THEN
C**   IF HEAT BUILDUP ON MAINT TEAM EXCEEDS 70
C**   INCREASE TIME TO COMPLETE TASK BY INCLUDING REST PERIOD
      S=A3(I)+40.19
C**   DECREASE HEAT BUILDUP ON MX TEAM
      TM = RT - 40.0
      V=E-40
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT
      CALL PATRB(TM,6)
      CALL PATRB(E,7)
      CALL GETAT(RATT)
C**   PLACE TRANSACTION INTO SYSTEM AT NEXT NODE
      CALL PTIN(SUM,S,TNOW,RATT)
      RETURN
      ENDIF
C**   IF A REST PERIOD WAS NOT REQUIRED
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT
      CALL PATRB(RT,6)
      CALL PATRB(E,7)
      CALL GETAT(RATT)
C**   PLACE TRANSACTION INTO SYSTEM AT NEXT NODE
      CALL PTIN(SUM,A3(I),TNOW,RATT)
      RETURN
C**
```

```
C**   LOAD MISSILES
C**   AIRCRAFT IS FUELED.  ALL AIRCRAFT ARE
C**   SCHEDULED TO HAVE MISSILES UPLOADED.
C**   THESE ARE EITHER AIR-TO-AIR OR AIR-
C**   TO-GROUND MISSILES.
C**
C**   GET AIRCRAFT NUMBER
 9    I = IFIX(GATRB(3) + 0.1)
C**   GET MX TEAM NUMBER WORKING ON AIRCRAFT
      J=IFIX(GATRB(4)+0.1)
      PRINT*,'TIME IS ',TNOW,' AIRCRAFT ',I,' MISSILES UPLOAD'
      DTIM = 600.0
C**   IF AIRCRAFT WAS JUST FUELED BY A FUEL TRUCK
      IF(NACTY(IDUM).LT.45) THEN
      DTIM=0.0
      ENDIF
C**   INCREASE HEAT BUILDUP ON MX TEAM
      RT=GATRB(6)+A9(I)
      E=GATRB(7)+A9(I)
C**   INCREMENT WORK TIME ON MX TEAM
      W(J)=W(J)+A4(I)
C**   CHECK NODE NUMBER IN SUBNETWORK
      SUM = NODCV(27,J)
      IF(RT.GT.70.0.OR.E.GT.70.0) THEN
C**   IF HEAT BUILDUP EXCEEDS 70, INCREASE TIME TO COMPLETE
C**   TASK BY INCLUDING REST PERIOD AND DECREASE HEAT BUILDUP
      S=A4(I)+48.19
      TM = RT - 40.0
      V = E - 40.0
      IF(TM.GT.70.0.OR.V.GT.70.0) THEN
C**   IF HEAT BUILDUP STILL EXCEEDS 70 WITH A REST PERIOD,
C**   DECREASE HEAT BUILDUP AND INCREASE TIME TO COMPLETE THE
C**   TASK WITH A SECOND REST PERIOD
      TM=TM-40.0
      V=V-40.0
      S=S+48.19
      ENDIF
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT AND INTO NEXT NODE
      CALL PATRB(TM,6)
      CALL PATRB(V,7)
      CALL GETAT(RATT)
      CALL PTIN(SUM,S,TNOW,RATT)
      RETURN
      ENDIF
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT AND INTO NEXT NODE
      CALL PATRB(RT,6)
      CALL PATRB(E,7)
      CALL GETAT(RATT)
      CALL PTIN(SUM,A4(I),TNOW,RATT)
      RETURN
```

```
C**   PREFLT
C**   UPON COMPLETION OF PREFLIGHT THE
C**   AIRCRAFT AWAIT A FORMATION TAKEOFF.
C**
C**   GET AIRCRAFT NUMBER
  9   I = IFIX(GATRB(3) + 0.1)
C**   GET MX TEAM NUMBER WORKING ON AIRCRAFT
      J=IFIX(GATRB(4)+0.1)
      PRINT*,'TIME IS ',TNOW,' AIRCRAFT ',I,' PREFLIGHT'
      DTIM = 600.0
C**   INCREASE HEAT BUILDUP ON MX TEAM
      RT=GATRB(6)+A11(I)
      E = GATRB(7) + A11(I)
C**   INCREMENT WORK TIME ON MX TEAM
      W(J)=W(J)+A5(I)
C**   CHECK NODE NUMBER IN SUBNETWORK
      SUM = NODCV(28,J)
      IF(RT.GT.70.0) THEN
C**   IF HEAT BUILDUP EXCEEDS 70, INCREASE
C**   TIME TO COMPLETE TASK BY INCLUDING
C**   REST PERIOD AND DECREASE HEAT BUILDUP
      S=A5(I)+48.19
      TM = RT - 40.0
      V = E - 40.0
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT
      CALL PATRB(V,7)
      CALL PATRB(TM,6)
      CALL GETAT(RATT)
C**   PLACE TRANSACTION INTO SYSTEM AT NEXT NODE
      CALL PTIN(SUM,S,TNOW,RATT)
C**   GET CURRENT TIME
      A12(J)=TNOW+S
C**   SET HEAT BUILDUP VALUES FOR START OF NEXT CYCLE
      A15(J)=TM
      A16(J)=V
      RETURN
      ENDIF
C**   IF REST IS NOT REQUIRED
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT
      CALL PATRB(RT,6)
      CALL PATRB(E,7)
      CALL GETAT(RATT)
C**   PLACE TRANSACTION INTO SYSTEM AT NEXT NODE
      CALL PTIN(SUM,A5(I),TNOW,RATT)
C**   GET CURRENT TIME
      A12(J)=TNOW+A5(I)
C**   SET HEAT BUILDUP VALUES FOR START OF NEXT CYCLE
      A15(J)=RT
      A16(J)=E
      RETURN
```

```
C**
C**   AIRCRAFT ARE AWAITING REFUELING
C**   BY THE FUEL TRUCKS.
C**
 10   I = IFIX(GATRB(3)+0.1)
      J=IFIX(GATRB(4)+0.1)
      DTIM=0.0
      A13(J)=TNOW
      RETURN
C**
C**
C**
C**
C**   A FUEL TRUCK IS AVAILABLE
C**   REFUELING STARTS AND THERMAL STRESS
C**   IS REDUCED ON THE MX TEAMS BY THE
C**   TIME REQUIRED TO FUEL THE AIRCRAFT
C**   AND THE TIME SPENT AWAITING REFUELING.
C**   THE NUMBER OF TRUCKS AVAILABLE IS
C**   SET IN ACTIVITY 37.
C**
C**   GET AIRCRAFT NUMBER
 11   I = IFIX(GATRB(3) + 0.1)
C**   GET MX TEAM NUMBER WORKING ON AIRCRAFT
      J=IFIX(GATRB(4)+0.1)
      PRINT*,'TIME IS ',TNOW,' AIRCRAFT ',I,' FUELED'
      DTIM=0.0
C**   FIND TIME THE AIRCRAFT WAITED PRIOR TO REFUELING
      A14(J)=TNOW-A13(J)
C**   GET HEAT BUILDUP VALUES FOR MX TEAM
      RT=GATRB(6)
      E = GATRB(7)
C**   REDUCE VALUES OF HEAT BUILDUP ON MX TEAM
C**   BY AMOUNT OF TIME AIRCRAFT AWAITED REFUELING
C**   AND TIME REQUIRED FOR REFUELING.
      TM=RT-A10(I)-0.83*A14(J)
      V=E-A10(I)-0.83*A14(J)
C**   PLACE VALUES IN ATTRIBUTES ON AIRCRAFT
      CALL PATRB(TM,6)
      CALL PATRB(V,7)
      CALL GETAT(RATT)
C**   PLACE TRANSACTION INTO SYSTEM AT NODE 39
      CALL PTIN(39,A10(I),TNOW,RATT)
      RETURN
C**
```

```
C**   THIS STOPS ALL ACTIVITIES THAT THE
C**   MX TEAM IS DOING IN THE MODEL AND
C**   MAKES THE TEAM AVAILABLE FOR
C**   REASSIGNMENT TO ANOTHER AIRCRAFT
C**
C**   GET AIRCRAFT NUMBER
 12   I=IFIX(GATRB(3)+0.1)
C**   GET MX TEAM NUMBER WORKING ON AIRCRAFT
      J=IFIX(GATRB(4)+0.1)
      DTIM=0.0
      CALL STSER(61)
      CALL STSER(40)
      K1=NATCV(19,J)
      K2=NATCV(21,J)
      K3=NATCV(22,J)
      K4=NATCV(27,J)
      K5=NATCV(29,J)
      K6=NATCV(34,J)
      CALL STSER(K1)
      CALL STSER(K2)
      CALL STSER(K3)
      CALL STSER(K4)
      CALL STSER(K5)
      CALL STSER(K6)
      RETURN
C**
C**   KEEPS TRACK OF THE FUEL TRUCKS
C**   EACH TRUCK IS ABLE TO FUEL TWO
C**   AIRCRAFT PRIOR TO IT NEEDING REFUELING
C**   STOP ARTIFICAL ACTIVITIES
 13   CALL STSER(42)
      CALL STSER(42)
      DTIM=0.0
C**   GET AIRCRAFT NUMBER
      I=IFIX(GATRB(3)+0.1)
C**   GET MX TEAM NUMBER WORKING ON AIRCRAFT
      J=IFIX(GATRB(4)+0.1)
      PRINT*,'TIME IS ',TNOW,' FUEL TRUCK ',I,J
      RETURN
C**
C**   KEEPS TRACK OF AIRCRAFT DESTROYED AND
C**   THE TIME OF OCCURANCE.  PROBABILITY
C**   IS SET IN QGERT MODEL, ACTIVITY 45,46.
C**
 14   DTIM=0.0
C**   GET AIRCRAFT NUMBER
      I=IFIX(GATRB(3)+0.1)
      DEST=DEST+1
      PRINT*,'AIRCRAFT ',I,' DESTROYED AT TIME ',TNOW
      RETURN
```

```
C**
C**   KEEPS TRACK OF AIRCRAFT DAMAGED AND
C**   THE TIME OF OCCURANCE.  PROBABILITY
C**   SET IN-QGERT MODEL, ACTIVITY 45,47.
C**
C**
C**   GET AIRCRAFT NUMBER
 15   I=IFIX(GATRB(3)+0.1)
C**   GET FLIGHT TIME
      RT=EX(1)
      S=TNOW+RT
      PRINT*,'AIRCRAFT ',I,' DAMAGED AND LANDED AT TIME ',S
      DAMG=DAMG+1
C**   SET ACTIVITY TIME TO FLIGHT TIME AND MX DELAY
C**   OF 240 MINUTES TO FIX AIRCRAFT
      DTIM=240.0+RT
      RETURN
C**
C**   AN AIR ABORT IS ANY FLIGHT THAT LASTS
C**   LESS THAN 15 MINUTES.  THESE FLIGHTS
C**   SHOULD BE SUBTRACTED FROM THE TRANS-
C**   ACTION PASSAGES OF NODE 5 TO OBTAIN
C**   A MORE ACCURATE COUNT OF SUCCESSFUL
C**   SORTIES.
C**
C**
C**   GET FLIGHT TIME
 16   RT=EX(1)
C**   GET AIRCRAFT NUMBER
      I=IFIX(GATRB(3)+0.1)
C**   SET ACTIVITY TIME TO FLIGHT TIME
      DTIM=RT
      IF(RT.LT.15.) THEN
C**   IF AIRCRAFT AIR ABORTS, SET ACTIVITY TIME TO
C**   FLIGHT TIME PLUS MAINT DELAY OF 240 MINUTES
C**   TO FIX AIRCRAFT
      DTIM=240.0+RT
      S=TNOW+RT
      PRINT*,'AIRCRAFT ',I,' AIR ABORT AND LANDED AT ',S
      AIRAB=AIRAB+1
      ENDIF
      RETURN
      END
      SUBROUTINE UO
      COMMON/QVAR/NDE,NFTBU(500),NREL(500),NRELP(500),NREL2(500),
     +NRUN,NRUNS,NTC(500),PARAM(100,4),TBEG,TNOW
      COMMON/RET/A1(50),A2(50),A3(50),A4(50),A5(50),A6(50),
     +A7(50),A8(50),A9(50),
     +A10(50),A11(50),A12(50),A13(50),A14(50),A15(50),A16(50),
     +N(16),IC(16)
```

```
      COMMON/VAR/I,J,K,L,N,X,AIRAB,DEST,DAMG,FLTS
      REAL LO
      INTEGER  PLUS,SUM,X,K1,K2,K3,K4,K5,K6,NUMB,
     +AIRAB,DEST,DAMG,FLTS
      PRINT*
      PRINT*,'****************************************'
      PRINT*
      PRINT*,'THE NUMBER OF FLTS GENERATED IS ',FLTS
      PRINT*,'THE NUMBER OF AIR ABORTS IS ',AIRAB
      PRINT*,'THE NUMBER OF DESTROYED AIRCRAFT IS ',DEST
      PRINT*,'THE NUMBER OF DAMAGED AIRCRAFT IS ',DAMG
      PRINT*
      DO 300 I=1,N
      PRINT*,'THE WORK TIME FOR TEAM ',I,' IS ',W(I)
  300 CONTINUE
      PRINT*
      PRINT*,'****************************************'
      RETURN
      END
```

```
GEN,TAFT,BASE16,11,01,1981,3,1,30,1440,1,F,0.,8,(21)90,61*
SOU,42,0,2000,D*                               START
REG,1,1,1,A*                                   GENERATE AIRCRAFT
REG,43,1,1,P*                                  FIRST LANDING
REG,3,1,1,D*                                   ASSIGN WING TANKS
REG,4,1,1,D*                                   ASSIGN NO WING TANKS
REG,5,1,1,F*                                   AIRCRAFT LAND
QUE,6/HOTPIT,0,0,D,F,8*                        HOTPIT
REG,7,1,1,F*                                   AIRCRAFT,FUELTRUCK FUELED
REG,8,1,1,F*                                   HOTPIT FILLED FOR AIRCRAFT
REG,9,1,1,D*                                   HOTPIT FILLED FOR FUELTRUCK
REG,10,1,1,D*                                  REFUEL FUELTRUCK
STA,11/TRKFILL,1,1,D,1*                        DATA ON FUELTRUCKS
REG,12,1,1,D*                                  RETURN FUEL TRUCKS
REG,49,1,1*                                    END LINE
REG,13,1,1,D*                                  TAXI TO RAMP
QUE,14,0,,,*                                   AWAIT TOW TRUCK
QUE,16/TOW,0,,*                                AIRCRAFT IN REVETMENT
QUE,51,0,0,D,F,B,50,50*                        AWAIT MX TEAM
REG,52,1,1*                                    END LINE
DEF,1*                                         MX TEAM 1
QUE,90,0,,(10)60,(50)02*
ALL,60,POR,1,1,90/50,(50)03*
REG,50,1,1,D,(50)04*
REG,18,1,1,A,(50)05*                           CHECK AIRCRAFT STATUS
REG,19,1,1,F,(50)06*                           CHECK IF FUELED
REG,21,1,1,P,(50)08*                           CHECK IF NEED WING TANKS
REG,23,1,1,P,(50)12*                           TANKS ON NOT FUELED
REG,24,1,1,D,(50)14*                           PUT WING TANKS ON
REG,25,1,1,D,(50)16*                           TAKE WING TANKS OFF
REG,26,1,1,D,(50)18*                           LEAVE ALONE
REG,15,1,1,D,(50)19*                           LINK AWAITING REFUELING
REG,27,1,1,D,(50)20*                           MISSILES UPLOADED
REG,28,1,1,D,(50)22*                           LINK PREFLIGHT
RES,1,1,60,(50)23*
VAS,18,4,CO,1,(50)24*
VAS,24,2,CO,1.,(50)26*
VAS,25,2,CO,0.,(50)28*
ACT,50,16,(6)50,(50)50*
ACT,18,19,US,4,19/AEROLOAD,(9)A2.GE.1,(50)51*
ACT,18,21,US,5,21/AEROLOAD,(9)A2.LT.1,(50)54*
ACT,19,27,US,8,22/MISSILES,(9)A2.GE.2,(50)56*
ACT,19,23,CO,0.,24,(9)A2.LT.2,(50)58*
ACT,21,26,CO,0.,26/LVALONE,,.5,(50)64*
ACT,21,24,US,6,27/TANKSON,,.5,(50)66*
ACT,23,25,US,7,29/TANKSOFF,,.5,(50)70*
ACT,23,26,CO,0.,30/LVALONE,,.5,(50)72*
ACT,24,15,(6)31,(50)73*                        CONNECT TO LINK
ACT,25,15,CO,0.,32,(50)74*                     CONNECT TO LINK
ACT,26,15,CO,0.,33,(50)76*                     CONNECT TO LINK
```

```
ALT,27,28,03,9,34/FREFLT,(50)78*
ESN*
DUP,2,E*                                MX TEAM 2
REP,03,ALL,60,POR,2,1,90/50*
REP,23,RES,2,1,60*
REP,24,VAS,18,4,CO,2*
ESN*
DUP,3,E*                                MX TEAM 3
REP,03,ALL,60,POR,3,1,90/50*
REP,23,RES,3,1,60*
REP,24,VAS,18,4,CO,3*
ESN*
DUP,4,E*                                MX TEAM 4
REP,03,ALL,60,POR,4,1,90/50*
REP,23,RES,4,1,60*
REP,24,VAS,18,4,CO,4*
ESN*
DUP,5,E*                                MX TEAM 5
REP,03,ALL,60,POR,5,1,90/50*
REP,23,RES,5,1,60*
REP,24,VAS,18,4,CO,5*
ESN*
DUP,6,E*                                MX TEAM 6
REP,03,ALL,60,POR,6,1,90/50*
REP,23,RES,6,1,60*
REP,24,VAS,18,4,CO,6*
ESN*
DUP,7,E*                                MX TEAM 7
REP,03,ALL,60,POR,7,1,90/50*
REP,23,RES,7,1,60*
REP,24,VAS,18,4,CO,7*
ESN*
DUP,8,E*                                MX TEAM 8
REP,03,ALL,60,POR,8,1,90/50*
REP,23,RES,8,1,60*
REP,24,VAS,18,4,CO,8*
ESN*
DUP,9,E*                                MX TEAM 9
REP,03,ALL,60,POR,9,1,90/50*
REP,23,RES,9,1,60*
REP,24,VAS,18,4,CO,9*
ESN*
DUP,10,E*                               MX TEAM 10
REP,03,ALL,60,POR,10,1,90/50*
REP,23,RES,10,1,60*
REP,24,VAS,18,4,CO,10*
ESN*
DUP,11,E*                               MX TEAM 11
REP,03,ALL,60,POR,11,1,90/50*
REP,23,RES,11,1,60*
```

```
REP,24,VAS,18,4,CO,11*
ESN*
DUP,12,E*                                MX TEAM 12
REP,03,ALL,60,POR,12,1,90/50*
REP,23,RES,12,1,60*
REP,24,VAS,18,4,CO,12*
ESN*
DUP,13,E*                                MX TEAM 13
REP,03,ALL,60,POR,13,1,90/50*
REP,23,RES,13,1,60*
REP,24,VAS,18,4,CO,13*
ESN*
DUP,14,E*                                MX TEAM 14
REP,03,ALL,60,POR,14,1,90/50*
REP,23,RES,14,1,60*
REP,24,VAS,18,4,CO,14*
ESN*
DUP,15,E*                                MX TEAM 15
REP,03,ALL,60,POR,15,1,90/50*
REP,23,RES,15,1,60*
REP,24,VAS,18,4,CO,15*
ESN*
DUP,16,E*                                MX TEAM 16
REP,03,ALL,60,POR,16,1,90/50*
REP,23,RES,16,1,60*
REP,24,VAS,18,4.CO,16*
ESN*
REG,44,1,1,F*                            LINK
QUE,29,0,,D*                             AWAIT REFUELING
QUE,37,0,0,D,,B*                         REFUELING
REG,38,1,1,D*                            FUEL TRUCK
REG,39,1,1,D*
REG,40,2,2,D,M*                          TRUCK EMPTY
FRE,70,,1,1*                             RELEASE MX TEAMS
FRE,71,,2,1*
FRE,72,,3,1*
FRE,73,,4,1*
FRE,74,,5,1*
FRE,75,,6,1*
FRE,76,,7,1*
FRE,77,,8,1*
FRE,78,,9,1*
FRE,79,,10,1*
FRE,80,,11,1*
FRE,81,,12,1*
FRE,82,,13,1*
FRE,83,,14,1*
FRE,84,,15,1*
FRE,85,,16,1*
STA,31/DONE,1,1,D,1*                     AIRCRAFT MX COMPLETE
```

```
REG,45,1,1,P*                                      AIRCRAFT LAND
STA,46,1,1,D,A*                                    AIRCRAFT DESTROYED
REG,47,1,1,D*                                      AIRCRAFT DAMAGED
SIN,32/ENDDAT,1,1,,1*                              END OF MODEL
VAS,1,3,IN,1,,4,CO,25.,5,CO,0.,6,CO,30.,7,CO,30.*
VAS,3,1,CO,1.,2,CO,0.0*
VAS,4,1,CO,0.0,2,CO,0.0*
VAS,5,8,US,2*
VAS,7,2,CO,2.*
VAS,13,2,CO,1.*
VAS,40,5,CO,1.*
VAS,46,8,US,14*
PAR,1,70.,0.,140.*
PAR,2,2.19,2.0,2.5,.1*                             TAXI TO HOTPIT
PAR,3,2.19,2.0,2.5,.1*                             TAXI TO HOTPIT
PAR,4,14.4,8.42,18.98,1.5*                         HOTPIT REFUEL
PAR,5,3.5,1.8,12.98,.7*                            TAXI TO SHELTER
PAR,6,2.0,.95,3.03,.3*                             DRIVE TRUCK
PAR,7,4.7,3.0,6.76,.6*                             TOW
PAR,8,1.15,0.73,1.65,0.15*                         AERO7
PAR,9,10.8,6.09,15.53,1.3*                         RELOAD
PAR,10,16.8,10.72,24.15,2.0*                       TANKS
PAR,11,31.25,19.94,44.94,2.8*                      MISSILES
PAR,12,5.9,3.77,8.49,0.6*                          PREFLT
PAR,13,16.8,10.72,24.16,2.0*                       FUEL
ACT,42,1,CO,235.,53/START*
ACT,1,1,CO,0.,1/PLANES,(9)A3.LE.23*
ACT,1,43,CO,0.,2/LAND,24,(9)A3.LE.24*
ACT,43,3,LO,2,3,24,0.5*
ACT,43,4,LO,3,4,24,.5*
ACT,3,45,(7)24*
ACT,4,45,(7)24*
ACT,5,6,CO,0.,7,24,(9)A1.GE.1.*
ACT,6,7,LO,4,11/FUEL,2*
ACT,8,9,CO,27.0,9,(9)A5.GE.1.*
ACT,5,14,LO,5,8,24,(9)A5.LT.1.*
ACT,8,13,CO,0.,10,(9)A5.LT.1.*
ACT,9,10,CO,0.,14*
ACT,7,10,CO,0.,13,(9)A5.GE.1.*
ACT,7,14,LO,5,12,(9)A5.LT.1.*
ACT,10,11,LO,6,15/DRIVETRK*
ACT,11,12,(6)15*
ACT,12,49,US,13,41*
ACT,13,14,LO,5,17*
ACT,14,16,LO,7,18/TOW,2*
ACT,16,51,US,9,60/ASSIGN*
ACT,51,52,CO,600,61/DEADEND,15*
ACT,44,29,US,10,36*
ACT,29,37,US,11*
ACT,37,38,CO,600,42,4*                             SET FUEL TRUCKS AVAILABLE
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ACT,39,40,US,6,40*                                          009240
ACT,40,6,LO,6,57*                                           009250
ACT,70,31,US,12*                                            009260
ACT,71,31,US,12*                                            009270
ACT,72,31,US,12*                                            009280
ACT,73,31,US,12*                                            009290
ACT,74,31,US,12*                                            009300
ACT,75,31,US,12*                                            009310
ACT,76,31,US,12*                                            009320
ACT,77,31,US,12*                                            009330
ACT,78,31,US,12*                                            009340
ACT,79,31,US,12*                                            009350
ACT,80,31,US,12*                                            009360
ACT,81,31,US,12*                                            009370
ACT,82,31,US,12*                                            009380
ACT,83,31,US,12*                                            009390
ACT,84,31,US,12*                                            009400
ACT,85,31,US,12*                                            009410
ACT,45,46,CO,0,(8)0.06*                                     009420
ACT,45,47,US,15,(8)0.09*                                    009430
ACT,45,5,US,16,(8)0.85*                                     009440
ACT,47,5,CO,240.,*                                          009450
ACT,31,32,US,1,45,1*                                        009460
LIN,15/1,44*                       LINK SUBNETWORK TO PROGRAM  009470
LIN,15/2,44*                                                009480
LIN,15/3,44*                                                009490
LIN,15/4,44*                                                009500
LIN,15/5,44*                                                009510
LIN,15/6,44*                                                009520
LIN,15/7,44*                                                009530
LIN,15/8,44*                                                009540
LIN,15/9,44*                                                009550
LIN,15/10,44*                                               009560
LIN,15/11,44*                                               009570
LIN,15/12,44*                                               009580
LIN,15/13,44*                                               009590
LIN,15/14,44*                                               009600
LIN,15/15,44*                                               009610
LIN,15/16,44*                                               009620
LIN,28/1,70*                                                009630
LIN,28/2,71*                                                009640
LIN,28/3,72*                                                009650
LIN,28/4,73*                                                009660
LIN,28/5,74*                                                009670
LIN,28/6,75*                                                009680
LIN,28/7,76*                                                009690
LIN,28/8,77*                                                009700
LIN,28/9,78*                                                009710
LIN,28/10,79*                                               009720
LIN,28/11,80*                                               009730
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LIN,28/12,01*
LIN,28/13,02*
LIN,28/14,03*
LIN,28/15,04*
LIN,28/16,05*
FIN*
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APPENDIX D
SAMPLE OUTPUT

The sample output gives a listing of all events that transpire for the last four hours of the model day. The listing shows these occurances based on time. The flow of an aircraft can be followed throughout its maintenance cycle. Fuel trucks are listed as to the time they are fueled and the number of the last aircraft they refueled. The amount of time the maintenance teams have worked is also followed.

The final section of output gives a listing of the number of flights, a flight consists of two aircraft, the number of air aborts, and destroyed and damaged aircraft. The total amount of time each team has worked is also listed.

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AIRCRAFT 11 PLACED IN NODE 5 AT 1201.73071835                         020020
TIME IS 1203.476605417 FUEL TRUCK 22 6                               020030
TIME IS 1207.495508047 AIRCRAFT 31 PREFLIGHT                          020040
AIRCRAFT 13 PLACED IN NODE 5 AT 1210.243752952                        020050
MAINT TEAM 15 WORKED 273.9162343047 TO THIS POINT.                    020060
AIRCRAFT 4 PLACED IN NODE 90/15 AT 1212.969839142                     020070
TIME IS 1212.969839142 ACRF 31.                                       020080
AIRCRAFT 31 AIR ABORT AND LANDED AT 1223.668489235                    020090
TIME IS 1212.969839142 AIRCRAFT 4 HAS NO WING TANKS                   020100
TIME IS 1215.860458447 AIRCRAFT 23 MISSILES UPLOAD                    020110
TIME IS 1218.800467081 AIRCRAFT 38 PREFLIGHT                          020120
AIRCRAFT 15 PLACED IN NODE 5 AT 1221.301657503                        020130
TIME IS 1222.017277386 AIRCRAFT 24 FUELED                             020140
AIRCRAFT 37 PLACED IN NODE 5 AT 1224.151001433                        020150
MAINT TEAM 2 WORKED 317.6325782493 TO THIS POINT.                     020160
AIRCRAFT 28 PLACED IN NODE 90/2 AT 1224.611818752                     020170
TIME IS 1224.611818752 ACRF 38.                                       020180
TIME IS 1224.611818752 AIRCRAFT 28 HAS WING TANKS                     020190
TIME IS 1225.899628017 AIRCRAFT 21 PREFLIGHT                          020200
TIME IS 1226.049291218 AIRCRAFT 45 FUELED                             020210
TIME IS 1227.263176316 AIRCRAFT 10 FUELED                             020220
TIME IS 1228.4200001 AIRCRAFT 30 PREFLIGHT                            020230
MAINT TEAM 11 WORKED 272.7872672551 TO THIS POINT.                    020240
AIRCRAFT 8 PLACED IN NODE 90/11 AT 1231.639634271                     020250
TIME IS 1231.639634271 ACRF 21.                                       020260
TIME IS 1231.639634271 AIRCRAFT 8 HAS NO WING TANKS                   020270
TIME IS 1234.645501678 AIRCRAFT 20 MISSILES UPLOAD                    020280
MAINT TEAM 8 WORKED 312.6497307146 TO THIS POINT.                     020290
AIRCRAFT 12 PLACED IN NODE 90/8 AT 1234.822952468                     020300
TIME IS 1234.822952468 ACRF 30.                                       020310
TIME IS 1234.822952468 AIRCRAFT 12 HAS WING TANKS                     020320
TIME IS 1237.085654058 AIRCRAFT 24 MISSILES UPLOAD                    020330
AIRCRAFT 26 PLACED IN NODE 5 AT 1237.467252248                        020340
TIME IS 1240.3643865 AIRCRAFT 40 MISSILES UPLOAD                      020350
TIME IS 1240.468812845 AIRCRAFT 45 MISSILES UPLOAD                    020360
TIME IS 1240.970681532 AIRCRAFT 8 TANKS PUT ON                        020370
TIME IS 1243.800756956 AIRCRAFT 10 MISSILES UPLOAD                    020380
TIME IS 1246.359305411 AIRCRAFT 12 MISSILES UPLOAD                    020390
AIRCRAFT 38 PLACED IN NODE 5 AT 1247.70435254                         020400
TIME IS 1251.712937072 AIRCRAFT 2 MISSILES UPLOAD                     020410
TIME IS 1260.910836913 FUEL TRUCK 10 13                               020420
TIME IS 1261.061911491 AIRCRAFT 41 FUELED                             020430
TIME IS 1267.441061145 FUEL TRUCK 24 5                                020440
AIRCRAFT 7 PLACED IN NODE 5 AT 1272.831463194                         020450
TIME IS 1273.372537506 AIRCRAFT 4 TANKS PUT ON                        020460
TIME IS 1273.391065271 AIRCRAFT 41 MISSILES UPLOAD                    020470
TIME IS 1282.48515843 AIRCRAFT 1 PREFLIGHT                            020480
AIRCRAFT 29 PLACED IN NODE 5 AT 1283.427622909                        020490
TIME IS 1284.028220195 AIRCRAFT 28 FUELED                             020500
TIME IS 1286.687686071 AIRCRAFT 4 FUELED                              020510
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MAINT TEAM 4 WORKED 355.?2?9473674 TO THIS POINT. 020520
AIRCRAFT 46 PLACED IN NODE 90/4 AT 1288.756451693 020530
TIME IS 1288.756451693 ACRF 1, 020540
TIME IS 1288.756451693 AIRCRAFT 46 HAS WING TANKS 020550
TIME IS 1298.921548502 AIRCRAFT 28 MISSILES UPLOAD 020560
TIME IS 1301.251005072 AIRCRAFT 33 PREFLIGHT 020570
TIME IS 1302.094708198 AIRCRAFT 4 MISSILES UPLOAD 020580
TIME IS 1305.282618059 AIRCRAFT 8 FUELED 020590
TIME IS 1306.003203873 AIRCRAFT 22 PREFLIGHT 020600
MAINT TEAM 1 WORKED 304.8593871436 TO THIS POINT. 020610
AIRCRAFT 32 PLACED IN NODE 90/1 AT 1307.221249182 020620
TIME IS 1307.221249182 ACRF 30. 020630
TIME IS 1307.221249182 AIRCRAFT 32 HAS WING TANKS 020640
MAINT TEAM 6 WORKED 322.3003156628 TO THIS POINT. 020650
AIRCRAFT 17 PLACED IN NODE 90/6 AT 1312.36677251 020660
TIME IS 1312.36677251 ACRF 22. 020670
TIME IS 1312.36677251 AIRCRAFT 17 HAS WING TANKS 020680
TIME IS 1315.850178476 AIRCRAFT 24 PREFLIGHT 020690
TIME IS 1317.817140136 FUEL TRUCK 28 2 020700
TIME IS 1317.916102467 AIRCRAFT 3 PREFLIGHT 020710
TIME IS 1318.931033946 AIRCRAFT 32 TANKS COMING OFF 020720
AIRCRAFT 30 PLACED IN NODE 5 AT 1321.898758683 020730
TIME IS 1322.744536567 AIRCRAFT 8 MISSILES UPLOAD 020740
AIRCRAFT 43 PLACED IN NODE 5 AT 1329.?32495592 020750
AIRCRAFT 21 PLACED IN NODE 5 AT 1331.486540638 020760
AIRCRAFT 47 PLACED IN NODE 5 AT 1331.590233558 020770
AIRCRAFT 33 PLACED IN NODE 5 AT 1340.078885724 020780
TIME IS 1340.078393379 FUEL TRUCK 8 11 020790
TIME IS 1344.589418375 AIRCRAFT 23 PREFLIGHT 020800
TIME IS 1346.550571541 AIRCRAFT 46 MISSILES UPLOAD 020810
MAINT TEAM 16 WORKED 322.4225980537 TO THIS POINT. 020820
AIRCRAFT 19 PLACED IN NODE 90/16 AT 1348.907509322 020830
TIME IS 1348.907509322 ACRF 23 020840
TIME IS 1348.907509322 AIRCRAFT 19 HAS WING TANKS 020850
TIME IS 1350.9315?9784 AIRCRAFT 41 PREFLIGHT 020860
AIRCRAFT 34 PLACED IN NODE 5 AT 1355.050704621 020870
AIRCRAFT 25 PLACED IN NODE 5 AT 1359.594549546 020880
TIME IS 1362.045005468 AIRCRAFT 20 PREFLIGHT 020890
TIME IS 1366.20385109 AIRCRAFT 45 PREFLIGHT 020900
MAINT TEAM 12 WORKED 313.1959663268 TO THIS POINT. 020910
AIRCRAFT 42 PLACED IN NODE 90/12 AT 1367.871818279 020920
TIME IS 1367.871818279 ACRF 28. 020930
TIME IS 1367.871818279 AIRCRAFT 42 HAS NO WING TANKS 020940
TIME IS 1368.024880586 AIRCRAFT 48 PREFLIGHT 020950
TIME IS 1370.903911776 AIRCRAFT 17 MISSILES UPLOAD 020960
MAINT TEAM 5 WORKED 309.335649391 TO THIS POINT. 020970
AIRCRAFT 5 PLACED IN NODE 90/5 AT 1371.272806478 020980
TIME IS 1371.272806478 ACRF 24. 020990
TIME IS 1371.272806478 AIRCRAFT 5 HAS WING TANKS 021000
AIRCRAFT 1 PLACED IN NODE 5 AT 1371.487184288 021010

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MAINT TEAM 7 WORKED 327.1534696971 TO THIS POINT.            021020
AIRCRAFT 11 PLACED IN NODE 90/7 AT 1371.604069441            021030
TIME IS 1371.604069441 ACRF 45.                              021040
AIRCRAFT 45 AIR ABORT AND LANDED AT 1380.351590718           021050
TIME IS 1371.604069441 AIRCRAFT 11 HAS WING TANKS            021060
TIME IS 1372.425119751 AIRCRAFT 10 PREFLIGHT                 021070
MAINT TEAM 3 WORKED 306.2908622292 TO THIS POINT.            021080
AIRCRAFT 13 PLACED IN NODE 90/3 AT 1372.499124314            021090
TIME IS 1372.499124314 ACRF 3.                               021100
TIME IS 1372.499124314 AIRCRAFT 13 HAS NO WING TANKS         021110
MAINT TEAM 14 WORKED 343.9054120477 TO THIS POINT.           021120
AIRCRAFT 15 PLACED IN NODE 90/14 AT 1373.02753095            021130
TIME IS 1373.02753095 ACRF 48.                               021140
TIME IS 1373.02753095 AIRCRAFT 15 HAS NO WING TANKS          021150
AIRCRAFT 48 DESTROYED AT TIME 1373.02753095                  021160
TIME IS 1373.970312199 AIRCRAFT 12 PREFLIGHT                 021170
MAINT TEAM 13 WORKED 318.4711387460 TO THIS POINT.           021180
AIRCRAFT 37 PLACED IN NODE 90/13 AT 1377.803377659           021190
TIME IS 1377.803377659 ACRF 10.                              021200
TIME IS 1377.803377659 AIRCRAFT 37 HAS WING TANKS            021210
MAINT TEAM 8 WORKED 361.2564944666 TO THIS POINT.            021220
AIRCRAFT 38 PLACED IN NODE 90/8 AT 1379.80971822             021230
TIME IS 1379.80971822 ACRF 12.                               021240
TIME IS 1379.80971822 AIRCRAFT 38 HAS WING TANKS             021250
TIME IS 1379.983317056 AIRCRAFT 2 PREFLIGHT                  021260
TIME IS 1381.863420556 AIRCRAFT 15 FUELED                    021270
TIME IS 1383.489701079 AIRCRAFT 13 TANKS PUT ON              021280
TIME IS 1383.837051501 AIRCRAFT 32 FUELED                    021290
TIME IS 1385.643307442 AIRCRAFT 37 MISSILES UPLOAD           021300
MAINT TEAM 9 WORKED 330.0201914821 TO THIS POINT.            021310
AIRCRAFT 26 PLACED IN NODE 90/9 AT 1385.987411337            021320
TIME IS 1385.987411337 ACRF 2.                               021330
TIME IS 1385.987411337 AIRCRAFT 26 HAS WING TANKS            021340
AIRCRAFT 9 PLACED IN NODE 5 AT 1390.24386519                 021350
AIRCRAFT 16 PLACED IN NODE 5 AT 1395.16079306                021360
TIME IS 1397.324127706 AIRCRAFT 15 MISSILES UPLOAD           021370
TIME IS 1398.084596454 AIRCRAFT 32 MISSILES UPLOAD           021380
AIRCRAFT 23 PLACED IN NODE 5 AT 1398.59987207                021390
AIRCRAFT 12 PLACED IN NODE 5 AT 1399.509593777               021400
TIME IS 1403.787304392 AIRCRAFT 8 PREFLIGHT                  021410
AIRCRAFT 44 PLACED IN NODE 5 AT 1405.062025024               021420
MAINT TEAM 10 WORKED 356.0637401442 TO THIS POINT.           021430
AIRCRAFT 7 PLACED IN NODE 90/10 AT 1405.439525619            021440
TIME IS 1405.439525619 ACRF 41.                              021450
TIME IS 1405.439525619 AIRCRAFT 7 HAS WING TANKS             021460
MAINT TEAM 11 WORKED 337.8855566463 TO THIS POINT.           021470
AIRCRAFT 29 PLACED IN NODE 90/11 AT 1410.57984137            021480
TIME IS 1410.57984137 ACRF 8.                                021490
TIME IS 1410.57984137 AIRCRAFT 29 HAS WING TANKS             021500
TIME IS 1411.266303433 AIRCRAFT 19 FUELED                    021510
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TIME IS 1415.808227079 AIRCRAFT 7 FUELED
TIME IS 1425.836310862 AIRCRAFT 19 MISSILES UPLOAD
TIME IS 1426.698080946 AIRCRAFT 28 PREFLIGHT
TIME IS 1427.105346528 AIRCRAFT 7 MISSILES UPLOAD
TIME IS 1427.593359801 AIRCRAFT 42 TANKS PUT ON
TIME IS 1428.842225299 AIRCRAFT 11 FUELED
TIME IS 1428.97843006 FUEL TRUCK 32 1
TIME IS 1431.676120708 AIRCRAFT 5 MISSILES UPLOAD
MAINT TEAM 2 WORKED 365.9656750564 TO THIS POINT.
AIRCRAFT 43 PLACED IN NODE 90/2 AT 1432.408235866
TIME IS 1432.408235866 ACRF 28.
AIRCRAFT 28 AIR ABORT AND LANDED AT 1441.238703907
TIME IS 1432.408235866 AIRCRAFT 43 HAS WING TANKS
TIME IS 1432.637711282 AIRCRAFT 4 PREFLIGHT
MAINT TEAM 15 WORKED 339.3339571806 TO THIS POINT.
AIRCRAFT 21 PLACED IN NODE 90/15 AT 1438.364576145
TIME IS 1438.364576145 ACRF 4.
TIME IS 1438.364576145 AIRCRAFT 21 HAS WING TANKS

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THE NUMBER OF FLTS GENERATED IS 49
THE NUMBER OF AIR ABORTS IS 27
THE NUMBER OF DESTROYED AIRCRAFT IS 5
THE NUMBER OF DAMAGED AIRCRAFT IS 14

THE WORK TIME FOR TEAM 1 IS 368.0690174765
THE WORK TIME FOR TEAM 2 IS 377.8115815487
THE WORK TIME FOR TEAM 3 IS 395.3309965899
THE WORK TIME FOR TEAM 4 IS 399.803354386
THE WORK TIME FOR TEAM 5 IS 351.8703972662
THE WORK TIME FOR TEAM 6 IS 364.7339081962
THE WORK TIME FOR TEAM 7 IS 336.2016255554
THE WORK TIME FOR TEAM 8 IS 373.741595663
THE WORK TIME FOR TEAM 9 IS 338.9512952658
THE WORK TIME FOR TEAM 10 IS 396.4871444678
THE WORK TIME FOR TEAM 11 IS 351.0729997414
THE WORK TIME FOR TEAM 12 IS 342.6810533424
THE WORK TIME FOR TEAM 13 IS 361.3390316327
THE WORK TIME FOR TEAM 14 IS 388.2015431148
THE WORK TIME FOR TEAM 15 IS 351.1382483981
THE WORK TIME FOR TEAM 16 IS 370.0256471523

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APPENDIX E

CHEMICAL DEFENSE ENSEMBLES

The material contained in this appendix came from two technical orders. The information on the Aircrew Chemical Defense Ensemble is from TO 14P3 - 1 - 131, and the information on the Groundcrew Ensemble is from TO 14P3 - 1 - 141. A majority of the material presented is directly quoted from these documents, therefore, quotations are not annotated or footnoted seperately.

Aircrew Chemical Defense Ensemble

The complete Aircrew Chemical Defense Ensemble consists of thirteen items. When worn together they protect users against toxic chemical agents. The diagrams of these items are shown in Figure 13. The numbers in the figure correspond to the numbered items described below.

1. <u>Protective Hood, HGU-41/P</u>. The HGU-41/P hood protects the head, neck, and shoulders. The hood is furnished in one size only. It has elastic around the neck to give a snug fit. Elastic webbing is used to give a snug fit around the face and visor portion of a CBO mask. Slide buckles are used to adjust the length of the underarm straps. Hook and pile fastener tape is used to close the front opening.

2. <u>Flyer's Helmet, HGU-39/P</u>. The HGU-39/P is a plastic shell with an energy-absorbing liner. The helmet is coated with white epoxy paint. It comes in Regular and Extra Large sizes, and provides head protection. An adjustable suspension and headband assembly inside the shell is used to improve fit. An adjustable retention system assembly is used to mount the ear cup assembly and chin strap. The ear assembly is used to hold the earphones.

3. <u>CBO Mask, MBU-13/P</u>. The CBO mask is a full face silicone mask with a butyl hose. The mask is used both on

the ground and in flight. It attaches to the filter assembly and to the aircraft radio system. It protects the eyes, face, nose, throat, and lungs from chemical agents. It has a rigid plastic faceplate, adjustable head harness, oxygen hose, nose cup, pressure compensated valves, microphone, and tabs for mounting eyeglasses.

4. CBO Mask Filter Assembly, CRU-80/P. The CBO Mask Filter Assembly is a butyl rubber flat pack with two M13A2 filter elements inside. A modified CRU-60/P assembly is mounted to the flat pack. The filter assembly can be used in air, or connected to an aircraft oxygen system or a bailout bottle, as needed. It cannot be used to protect against ammonia or carbon monoxide fumes, or in an oxygen deficient atmosphere.

5. Suspension Strap Assembly PN 854-17 or EC-100-815-M1. The suspension strap assembly (also called a Waist/Shoulder Strap Assembly) is an adjustable nylon or cotton strap with snap hooks on both ends. For crew members who do not wear parachute harnesses, these straps hold the CRU-80/P filter assembly in place.

6. Filter Elements Type M13A2. The M13A2 filter element set is used with the CRU-80/P filter assembly. Incoming air is routed through the filtering materials of the element to the CBO mask inlet port.

7. White Cotton Undershirt and Cotton Drawers. These items are 100% cotton. These items are worn under the flyer's undercoverall to prevent skin irritation from the charcoal lining and to limit perspiration taint of the coverall.

8. Flyer's Undercoverall, Chemical Protective. This one piece coverall is made from a non-woven fabric. The fabric is treated with a fluorochemical which protects from organic chemicals. The inner surface is coated with activated charcoal.

9. Plastic Tube Socks. The plastic tube socks protect the feet from chemical agents. They are made from 4 mil polyethylene. They are worn over cotton socks inside the flyer's boot.

10. Plastic Overboots. The overboots are worn over the flyer's boot. They protect the user from contamination enroute from the shelter and the aircraft. They are removed before entering the aircraft or shelter.

11. Plastic Disposable Cape. The disposable cape is a large plastic bag worn over the body. It protects the user from contamination enroute from the shelter and the aircraft. It is removed before entering the aircraft or shelter.

12. Gloves, Chemical Protective and White Cotton Inserts. The chemical protective gloves protect the hands from chemical agents. They are made of neoprene, and are

17 mil thick and 12 inches long. They are worn over optional absorbant white knit cotton inserts. The neoprene gloves can be worn over or under the Nomex flyer's gloves at the option of the MAJCOM.

13. Optional Skull Cap. This optional item keeps the user's hair away from the mask sealing area, preventing leaks. The cap also helps to prevent hot spots.

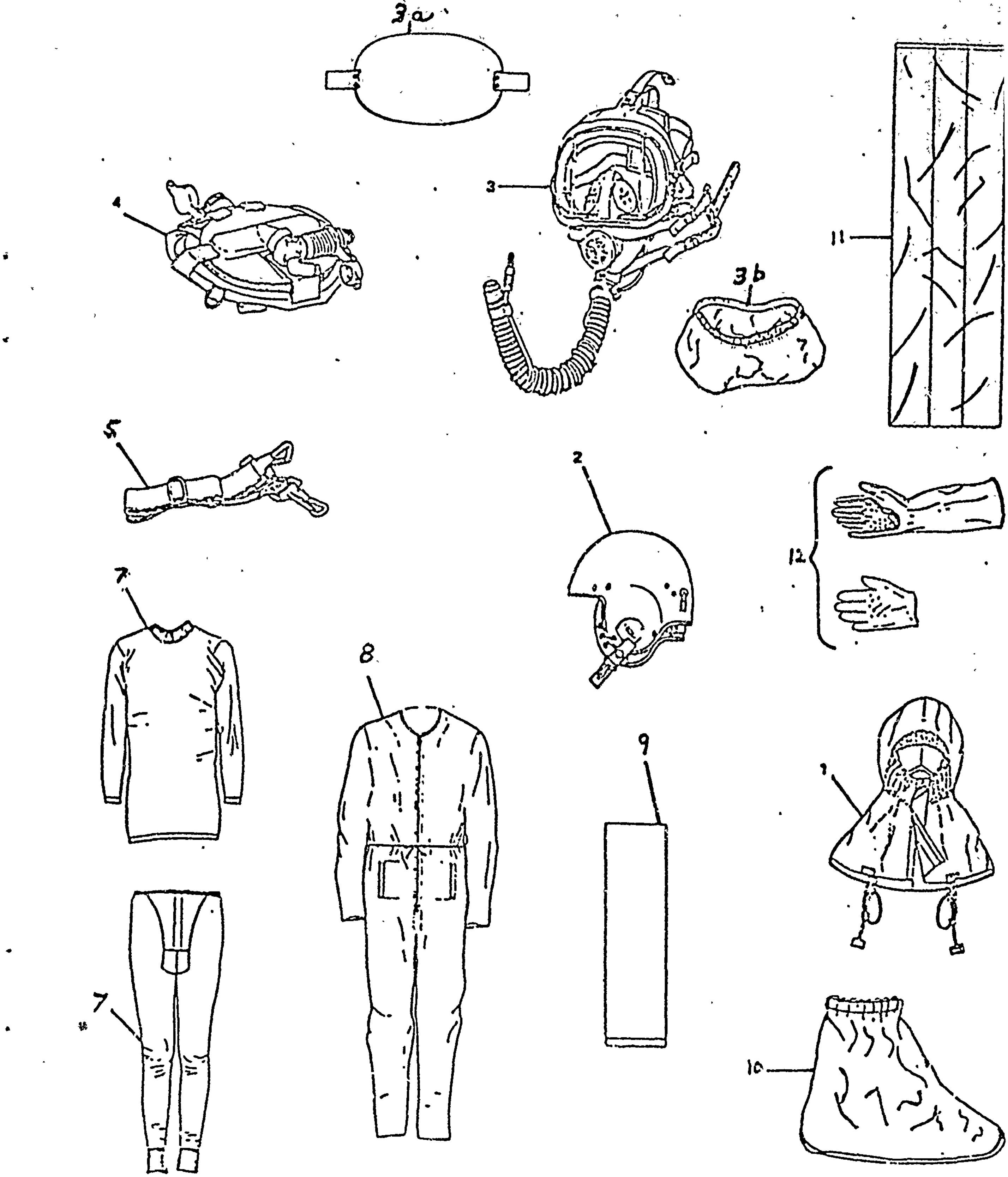

Fig. 13 Aircrew Chemical Defense Ensemble

Groundcrew Chemical Defense Ensemble

The Groundcrew Ensemble will be briefly described, and the purpose of the individual items. Figure E-2 shows the ensemble as it looks while being worn.

1. M6A2 Protective Hood. The M6A2 Hood is made of butyl rubber coated nylon cloth. It covers the head and neck of the wearer. When properly fitted to the protective mask, it provides protection against vapors, aerosols, and agent droplets. The hood does not protect against radiation. It will prevent the wearer from being contaminated with radioactive materials or dust. The hood covers the head without interfering with the combat helmet.

2. M17A1 Protective Mask. The M17A1 mask consists of the facepiece assembly, a pair of eyelens outserts, and a mask carrier. It is a combat mask which protects the face, eyes, and respiratory tract of the wearer from field concentrations of chemical and biological agents.

3. Chemical Protective Suit. The Chemical Protective Suit (Overgarment) is a two-layer permeable fabric, jacket and trouser suit designed to be worn over long sleeve fatigues and normal underclothing. The garmant outer layer is a nylon/cotton twill, dyed olive drab, and treated with a water resistant chemical. The inner layer is a charcoal impregnated polyurethane foam laminated to nylon tricot. It is intended primarily for protection of per-

sonnel exposed to vapors, aerosols, and liquid droplets of blister agents and nerve agents in the field.

4. Chemical Protective Footwear Covers. The Chemical Protective Footwear Cover (Overboot) is a butyl rubber boot. The footwear covers are designed to exclude contamination from the boots and feet, and provide a rapid means for removal of the contamination.

5. Chemical Protective Glove Set. The Chemical Protective Glove Set consists of a pair of 14.5 inch length, 0.025 inch thick butyl rubber outer gloves and a pair of thin white inner cotton gloves. They are designed to exclude contamination from the hands, and provide a rapid means for removal of contamination. Since the outer cover does not allow the passage of air, the cotton inner glove serves to absorb perspiration.

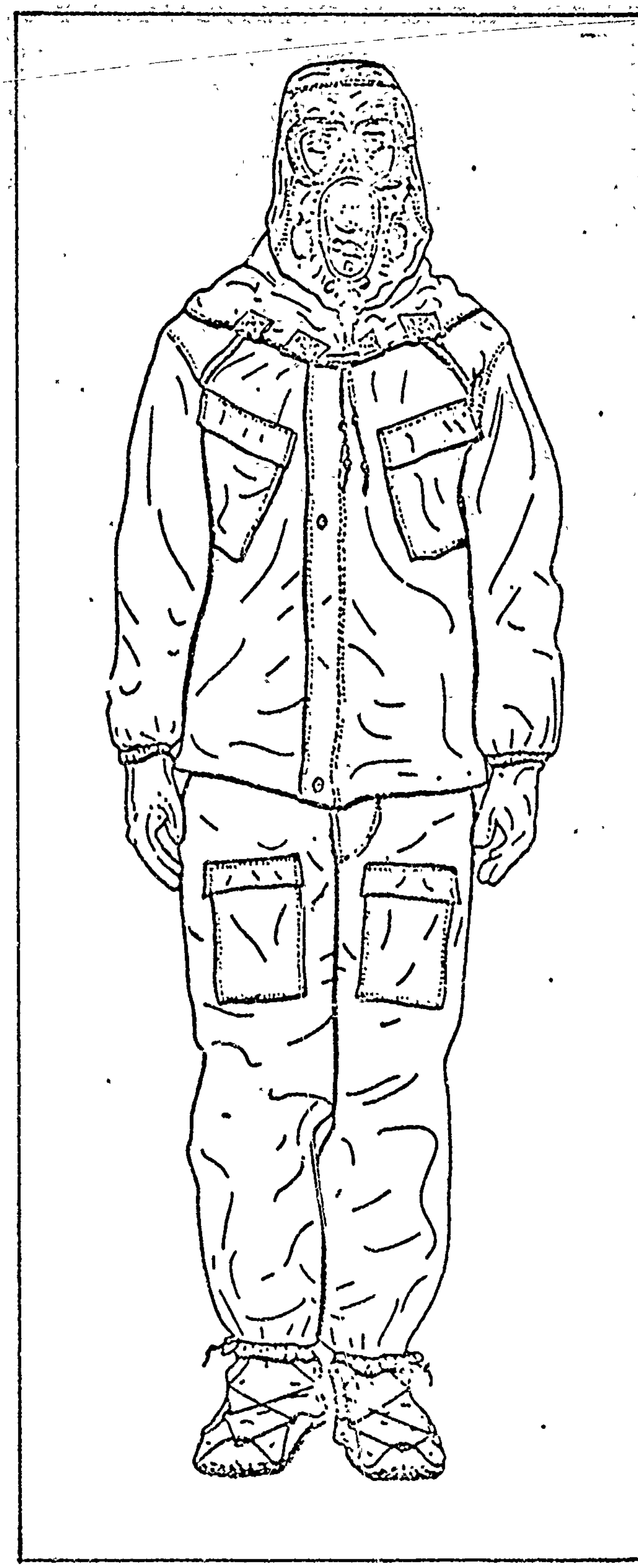

Fig. 14 Groundcrew Chemical Defense Ensemble

APPENDIX F

Data for Table VII

H_0: There is no difference between the treatments, the level of aircraft.

H_1: There is a difference.

With $\alpha = .05$ $\quad X^2_{4, .95} = 9.488$

Reject H_0 if T_4 exceeds $X^2_{4, .95}$

$E(R_j) = 99$

$Var\ (R_j) = 128$

$T_4 = 51.722 > X^2_{4, .95}$ so reject H_0

$\left| R_j - R_i \right| > 22.343$ with $\alpha = .05$ and $t_{1-\alpha/2} = 2.0$

R_3 and R_4 are not different. There is not a significant difference in aircraft generated with start-up conditions of 36 to 42 aircraft. There is a difference between all other levels.

Data for Table VIII

H_0: There is no difference between the treatments, the level of maintenance teams.

H_1: There is a difference.

With $\alpha = .05$ $\quad X^2_{8}, .95 = 15.51$

Reject H_0 if T_4 exceeds $X^2_{8}, .95$

$E(R_j) = 95$

$Var\ (R_j) = 252.549$

$T_4 = 78.404 > X^2_{8}, .95$ so reject H_0

$|R_j - R_i| > 13.954$ with $\alpha = .05$ and $t_{1-\alpha/2} = 2.0$

R_6 and R_7 are not different. There is not a significant difference between having 13 or 14 maintenance teams available.

Data for Table X

H_0: There is no difference between the treatments, the level of aircraft.

H_1: There is a difference.

With $\alpha = .05$ $\quad X^2_{4}, .95 = 9.488$

Reject H_0 if T_4 exceeds $X^2_{4}, .95$

$E(R_j) = 99$

$Var(R_j) = 131.467$

$T_4 = 73.36 > X^2_{4}, .95$ so reject H_0

$|R_j - R_1| > 11.4212$ with $\alpha = .05$ and $t_{1-\alpha/2} = 2.0$

They are all different.

Data for Table XI

H_0: There is no difference between the treatments, the level of maintenance teams.

H_1: There is no difference.

With $\alpha = .05$ $\quad X^2_{8}, .95 = 15.51$

Reject H_0 if T_4 exceeds $X^2_{8}, .95$

$E(R_j) = 95$

$\mathrm{Var}\ (R_j) = 234.144$

$T_4 = 74.420 > X^2_{8}, .95$ so reject H_0

$|R_j - R_i| > 24.065$ with $\alpha = .05$ and $t_{1-\alpha/2} = 2.0$

The following treatments are not different:

R_1 and R_2; R_2 and R_3; R_3 and R_4; R_4 and R_5; R_6 to R_8; and R_7 to R_9. There is not a significant difference by increasing the level of maintenance teams by one except between 12 and 13 teams.

Vita

Captain Robert Edward Taft was born on 3 September, 1950 in Chester County, Pennsylvania. He graduated from high school in Virginia Beach, Virginia in 1968. Upon graduation from the U.S. Air Force Acadamy, with Bachelor of Science Degrees in History and Soviet Area Studies, he was commissioned in the U.S. Air Force. He attended Pilot Training at Vance AFB, Oklahoma and went on to fly MC-130 Special Operations Aircraft. He entered the School of Engineering, at the Air Force Institute of Technology, in the Strategic and Tactical Sciences Program in August of 1980.

Captain Taft is married to the former Miss Lara Edmonston of Moore, Oklahoma. They have a daughter, Jennifer, and a son, Robert, Jr.

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1. REPORT NUMBER AFIT/GST/OS/82M-14	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AIRBASE OPERATIONS IN A CHEMICAL ENVIRONMENT		5. TYPE OF REPORT & PERIOD COVERED MS Thesis
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert E. Taft Captain		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Institute of Technology AFIT/EN, Wright-Patterson AFB, OH 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE March 1982
		13. NUMBER OF PAGES 127
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Approved for public release; IAW AFR 190-17

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WRIGHT-PATTERSON AFB, OH 45433

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aircraft Generation

Chemical Defense

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This thesis studies the effects of maintenance operations on a fighter base in a chemical environment. The desired goal is to determine if current manning for flight line maintenance is sufficient to support air operations.

A simulation model was developed to model the required tasks of maintenance in a wartime surge. The effects of wearing chemically protective clothing were incorporated to measure the results of operating with different numbers of aircraft and maintenance available. Analysis was performed using nonparametric

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tests, due to the nature of the data. The results of these tests indicate that the present manning is not sufficient.

Material is presented in the appendices that shows the nature of improvements being made in the chemical defense ensembles and aircraft systems. These improvements may reduce the limitations that are present in the current equipment used.